SCHOOL SCIENCE
AND
MATHEMATICS

VOL. XLVII JANUARY, 1947 WHOLE NO. 408

THE ATMOSPHERE OF THE SUN*

ORREN MOHLER, *Assistant Director*
McMath-Hulbert Observatory, University of Michigan

When a dweller on the earth refers to the atmosphere, he means the shell of gas surrounding the permanent rocky structure upon which he lives. With this in mind, it may seem strained to call one of the many gaseous layers of the sun its atmosphere, for the sun is completely gaseous throughout, and there is nowhere a surface of demarcation as definite as that separating the continents and the oceans from the air above them. But there is a layer of the sun that bears some resemblance to the earth's atmosphere. It is called the chromosphere.

The chromosphere of the sun is invisible, like our own atmosphere. Extraordinary conditions and methods such as total solar eclipses, or filters that make it possible to view the sun in light of single, very pure, colors are required for its observation. If we look at the sun, taking care to protect our eyes by dark, or heavily smoked glass, we do not see the chromosphere, but another gaseous surface, called the photosphere. The photosphere forms a gaseous base on which the solar chromosphere rests and above which it rises to a height of eight thousand miles. As soon as the photosphere has been completely covered by the eastward motion of the moon at the time of a total solar eclipse, the chromosphere flashes into view as a thin bright red line, apparently on the eastern edge of the moon. It may form a nearly complete circle around the moon before it disappears

* Presented at the annual convention of the Central Association of Science and Mathematics Teachers in Detroit, Michigan, November 30, 1946.

on the east, only to re-appear on the western edge of the moon just before the end of totality. Observing under these conditions, the telescope shows the chromosphere made up of innumerable small spikes; like a fringe of short, wooly, red hair.

Early observers of the chromosphere at eclipses were so impressed by the brightness of the red layer that they tried to observe it on the uneclipsed sun with the aid of a spectroscope. Such observations can be made. The spectroscope serves merely as a powerful filter, rejecting unwanted light and transmitting only red rays of the color observed at eclipse time. Very briefly, the procedure is as follows. A spectroscope is attached to an ordinary telescope, with the slit of the spectroscope in the usual position of the telescope eyepiece. The telescope is pointed so that the image of the sun is just tangent to the spectroscope slit. Looking through the eyepiece of the spectroscope one will see a continuous spectrum of skylight, crossed by bright lines of light from the solar chromosphere. If the slit of the spectroscope is widened until the bright red line of the chromosphere is only slightly brighter than the skylight, the furry structure of the chromosphere can be seen almost as well as at an eclipse. It is not possible to make the slit of the spectroscope very wide. Hence, the area of the sun visible at any one setting of the instrument is very small.

Frequent suggestions were made, after the success of the method was established, that the defect of a small field of view be remedied by moving the spectroscope rapidly back and forth across the image of the sun to form a wide field by persistence of vision, but there were many years of development necessary before a satisfactory spectroscopic filter for visual use was perfected. However, such instruments have been devised for making both visual and photographic observations, and the solar chromosphere is now subjected to routine daily observation.

What do the observations of the solar chromosphere reveal?

Outstandingly, they show that, differing from the relatively motionless photosphere, the chromosphere is a region where fantastically rapid motions and changes in light intensity are the rule. Speeds of twenty-five miles per second are commonplace. Small areas of the chromosphere may change their brightness by ten times the original value, either brightening or darkening. Large volumes of the chromospheric gases occasionally are ejected, travel away from the sun for half a

million miles or more, then return leisurely (forty miles per second). Many of the most spectacular changes require less than thirty minutes to run their full course from initial outbreak to the resumption of the normal state of chaos.

It is difficult to obtain adequate records of variations as rapid as those taking place in the chromosphere by any means

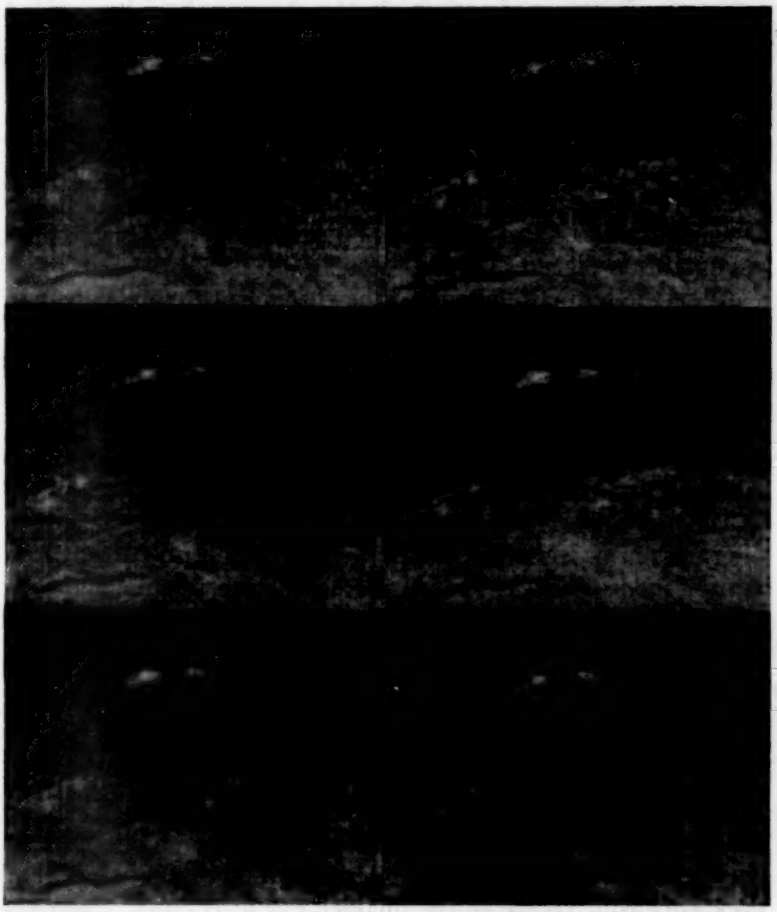


FIG. 1

DEVELOPMENT OF A SOLAR FLARE

September 16, 1939

$15^h\ 31^m\ 50^s$	$15^h\ 47^m\ 52^s$
$15^h\ 51^m\ 41^s$	$15^h\ 55^m\ 26^s$
$15^h\ 59^m\ 11^s$	$16^h\ 02^m\ 19^s$

other than motion picture techniques. Accordingly, Dr. Robert R. McMath, Director of the McMath-Hulbert Observatory of the University of Michigan, devised and constructed a combination of the motion picture camera and the spectro-heliograph (the finally adopted name of the spectroscopic filter for photographing the chromosphere) that provides a practically continuous record of any desired chromospheric disturbance. The resulting motion pictures of activity in the chromosphere have aided astronomers in interpreting the observations of former years by showing the variations in greater detail and they have made it possible to record short-lived disturbances that had formerly been observed only accidentally. All descriptions of chromospheric phenomena have been made more accurate by incorporating the results displayed in motion picture records: the following descriptions are especially dependent upon data gathered using motion pictures.

All of the normal "fauna" of the chromosphere are shown on the accompanying figure. They are, with two exceptions, visible nowhere else on the sun. The two exceptions are the sunspots (Figure 1, A) and the plages (Figure 1, B). Both sunspots and plages are visible in the photosphere, as well as in the chromosphere of the sun, although the plage is generally called a facula when observed in the photosphere.

The prominence (Figure 1, C) is a rather under-sized example of a class of objects that are uniquely chromospheric features. A prominence is an extension of the chromosphere that often rises thirty thousand miles above the general level of the sun's atmosphere. When viewed against the background of the sky, a prominence appears bright (Figure 1, C); but viewed against the disk of the sun with the bright chromosphere as a background, a prominence appears dark (Figure 1, D). These objects appear everywhere on the disk of the sun, but they show some slight avoidance of the polar regions. They are of all sizes and shapes, and degrees of activity. Some are objects so minute that they test the power of the best telescopes; some are so large that they are easily visible to the unaided eye at eclipses. Their activity varies from apparent immobility to motions as great as 400 miles per second. The largest and fastest moving, it need only be mentioned, are rare.

The newest name given to a type of chromospheric object is "flare." A flare is a sudden brightening of a part of the solar disk. These outbursts of light never occur outside of the bright,

but not rapidly variable, large areas called plages. The sudden brightening of the solar surface produces sudden and violent motions in the neighboring chromospheric gases. Shortly after the start of a flare a large cloud of gas starts to move rapidly away from the sun, only to reverse its motion and return as the flare fades. The entire performance is completed in about forty minutes.

Figure 1 is a sequence of pictures taken from the motion picture record of a flare that occurred in the area near a sunspot that happened to be located on the edge of the sun. This accidental position makes it possible for us to see the disturbance in profile. The crater formation with the spike-like prominences rising from the central cone is the sunspot. The flare disturbance is indicated in the first picture only by the minute brightening just to the left of the spot (the arrow points to the flare). The second picture follows sixteen minutes after the first and the flare is already well developed. A large column of chromospheric material has been thrust upward. Measures on the original record show that the speed of ejection of the material in the column was forty-five miles per second. The succeeding pictures show the return of the ejected material at a slightly lower speed. Assuming normal chromospheric density for the material in the column, the total mass ejected is 200,000,000 tons. The surface of the column is roughly equal in area to the area of the earth, but its total mass is about one part in ten million of the mass of the earth's atmosphere. Thus, while the disturbance is extensive, only a relatively small mass is involved because of the extremely small density of chromospheric material. The pictures actually portray the behavior of a nearly perfect vacuum.

Tenuous as these objects are, they are able to cause serious disruptions of radio communication on the earth. Complete fade-outs of long-distance short-wave radio transmission and reception often begin simultaneously with the appearance of flares on the sun. Interference with communications is among the least of the effects of the sun on the earth, but success in relating a terrestrial disturbance to an observable phenomenon on the sun has renewed the solar astronomer's hope that eventually all, or many, of the observable features on the sun can be advantageously interpreted.

Consideration for others is a good brand of charity.

SOME DEMONSTRATIONS FOR BEGINNING CHEMISTRY

ROBERT H. LONG
Green Mountain Junior College, Poultney, Vermont

The following demonstrations have been very useful in teaching beginning chemistry and therefore they are passed along to other teachers for what they may be worth. With the increased emphasis on general concept teaching in the lower levels of the sciences, a wider exchange of classroom demonstrations can do much to improve instruction in these areas. The writer is grateful for the many useful demonstrations passed on by other teachers and is offering these in exchange for such information.

SOLUBILITY OF ETHER IN WATER

Often in the study of the solubility of liquids in each other the degree of solubility is passed over lightly and the tag "insoluble" is sometimes carelessly placed on certain mixtures. The extent to which one apparently insoluble liquid will dissolve in another can easily be demonstrated with ether and water. Place some water in a test tube and mark the level with a wax pencil or some other suitable device. Carefully add a few milliliters of ether to the top of the water and observe the level of the intersurface of the two liquids. Shake the contents of the tube well, allow the suspension to separate; and the change in the level of the intersurface will show the approximate degree of solubility.

THE ACTION OF AQUA REGIA

The chemical reaction of aqua regia is generally passed over in most courses as a statement of fact. This important information can be converted into an excellent reasoning problem following the study of the two acids. Small quantities of nitric and hydrochloric acids are placed in separate beakers and moistened sheets of potassium iodide starch paper held over each as a control. Then as the acids are mixed one of the papers is held over the beaker containing the mixture. The darkening of the paper will give the clue to the reaction. The students can then review the cause of the change in the color of the paper with the related equations. This can be followed with a discussion of the change in the valence of the chlorine atoms, figuring out what has been reduced, review of the properties of the two acids and finally

the inspection of the equation representing the reaction between the two acids.

Water Solution of Iodine as an Oxidizing Agent

An interesting demonstration of the oxidizing property of iodine water can be shown along with that of bromine and chlorine water can be made by using a freshly prepared solution of sulfurous acid and barium chloride. Add a small portion of the latter to some iodine water and the formation of the white precipitate of barium sulfate as the barium sulfite is oxidized will afford clear evidence of the oxidation process. A test tube containing some of the sulfurous acid-barium chloride solution can be placed beside the tube containing the iodine as a control to show that not all of the oxidation was due to oxygen from the air.

The Reversible Reaction between Carbon Dioxide and Water

Rather than passing over the reaction between carbon dioxide and water by writing a reversible equation with a notation that temperature will determine the direction of greatest change, bromthymol blue indicator can be used to make an interesting demonstration of the reaction. At the same time the effect of temperature on the direction of greatest change can be shown. Add one or two drops of bromthymol blue indicator to a beaker containing about one hundred milliliters of distilled water that is at room temperature. Pass carbon dioxide through the solution until the color changes from blue to yellow. With an equation and a pH chart showing the point of color change of the indicator, the formation of carbonic acid can be explained. (The pH chart for bromthymol blue can be made on a large scale and kept for future use.) Then warm the beaker and its contents over a flame until the yellow color charges back to blue. Allow the students to work out the reasons for this change in color from the chart along with writing an equation for the latter reaction.

Chemical Reaction Models

Every teacher of chemistry has had to deal with students who could not balance equations because they "did not make sense." This fault can often be traced to poor power of visualization on the part of the students. Low grades, lack of interest, and dislike of a science can sometimes be traced back to this difficulty.

One way to make the concept of the chemical reaction, and hence the significance of the equation, is to use a set of blocks that are cut to approximate atomic weight proportions and marked with the atomic weights and symbols. The blocks should be drilled at proper places so that small connecting pegs representing the valence bonds can be inserted for building molecules. Students can be given molecules representing the reactants and instructed to make them over into certain molecules representing the products. The student can tally the number of molecules used, the number formed, and the number of atoms involved. From this information the equation can be written. The follow-

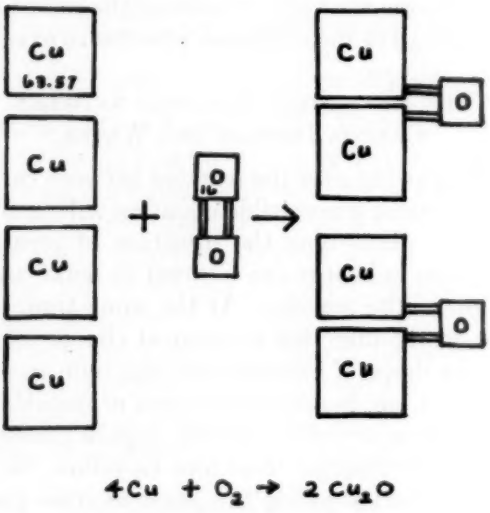


FIG. 1. Oxidation of copper.

ing diagram shows how the blocks are used to work out the equation for the oxidation of copper. Here the student starts with four atoms of copper and one molecule of oxygen. After rearranging the atoms to meet the valence requirements of oxygen the student will end up with two molecules of copper oxide.

Star finder, a simple instrument for amateur astronomers, is designed on the same principle as the equatorial mounting of the astronomer's telescope. It can be mounted on any standard camera tripod. With it, students can locate and identify constellations and stars.

AN EXPERIMENTAL DETERMINATION OF *e*

R. F. GRAESSER

University of Arizona, Tucson, Arizona

The writer's classes in plane geometry have been interested in the experimental determination of *pi*, using the solution of Buffon's problem in the theory of probability.[1] The value of *e* can also be obtained experimentally by using De Montmort's problem in a similar way. This problem was published with its solution in De Montmort's pioneer work on probability, *Essai d' Analyse sur les Jeux de Hazard*, which appeared in 1708. It should, perhaps, be remarked at the outset that these methods are of theoretical interest rather than practical value. The solution of De Montmort's problem depends upon the possible number of derangements of n objects, all different and having a natural or an assigned order. The number of arrangements or permutations of n such objects is $n!$. We have a derangement when no one of the n objects is in its natural or assigned place. For example, the letters a, b, c, d may be said to be in their natural order. They have the following possible arrangements:

abcd	abdc	acbd	acdb	adbc	adcb
bacd	*badc*	bcad	*bcda*	*bdac*	bdca
cabd	*cadb*	cbad	cbda	*cdab*	*cdba*
dabc	dacb	dbac	dbca	*dcab*	*dcba*

Of these the nine in italics are derangements since no one of the letters is in its proper place of the natural order. The formula for the number of derangements of n objects all different is

$$n!\left(1-\frac{1}{1!}+\frac{1}{2!}-\frac{1}{3!}+\cdots+(-1)^n\frac{1}{n!}\right). \qquad (1)$$

This formula is easily verified for the case of n equal four above. We now proceed to establish it in general. For concreteness let us think of the letters of the alphabet again although n may have any positive, integral value. Of the $n!$ arrangements of n such letters, some will have the first element a in its proper place and some will have a out of place. Now the number of arrangements with a in place is $(n-1)!$, for we then have only $(n-1)$ elements to arrange. Therefore, the number of arrangements with a out of place is $n!-(n-1)!$. Of these some will have

[1] Numbers refer to the references at the end.

b in place and some will have b out of place. If we put b in its proper place, we shall have one less element to arrange so that the number of arrangements of these with a out of place is $(n-1)!-(n-2)!$ by taking n equal to $n-1$ in $n!-(n-1)!$. Subtracting these with b out of place from those with b both in and out of place, we have $n!-2(n-1)!+(n-2)!$ for the number of arrangements with a and b out of place. Of these $(n-1)!-2(n-2)!+(n-3)!$ have c in place and

$$n!-2(n-1)!+(n-2)!-[(n-1)!-2(n-2)!+(n-3)!]$$
$$=n!-3(n-1)!+3(n-2)!-(n-3)!$$

with a, b, c out of place. Continuing in this way,

$$n!-4(n-1)!+6(n-2)!-4(n-3)!+(n-4)!$$

arrangements have the first four elements a, b, c, d out of place. The coefficients of these expressions are those of the binomial expansion so that, for the first r elements out of place, we have

$$n!-r(n-1)!+\frac{r(r-1)}{2!}(n-2)!-\frac{r(r-1)(r-2)}{3!}(n-3)!+\cdots$$
$$+(-1)^r\frac{r!}{r!}(n-r)!.$$

If r is equal to n, all elements are out of place so that the number of derangements of n objects all different is

$$n!-n(n-1)!+\frac{n(n-1)}{2!}(n-2)!-\frac{n(n-1)(n-2)}{3!}(n-3)!+\cdots$$
$$+(-1)^n\frac{n!}{n!}O!,$$

where $O!$ is equal to one, which is identical to (1).

De Montmort's problem may be stated thus. An urn contains n numbered balls which are otherwise identical. If they are drawn at random one at a time without replacements until all are drawn, what is the probability that no ball will appear in the draw corresponding to its number? In other words, what is the probability that ball number one will not appear on the first draw, and ball number two will not appear on the second draw, and so on? The *a priori* probability of a contingent event is defined as the number of ways the event can happen divided by the number of ways the event can happen or fail, all ways

being equally likely to occur. In our problem the number of ways the event can happen is given by (1), while the number of ways the event can happen or fail is $n!$. Hence the required probability P is

$$P=1-\frac{1}{1!}+\frac{1}{2!}-\frac{1}{3!}+\cdots+(-1)^n\frac{1}{n!}.$$

By the well-known Maclaurin expansion,

$$e^x=1+\frac{x}{1!}+\frac{x^2}{2!}+\frac{x^3}{3!}+\cdots,$$

which is valid for all values of x. If $x=-1$, we have

$$e^{-1}=1-\frac{1}{1!}+\frac{1}{2!}-\frac{1}{3!}+\cdots$$

so that

$$P=e^{-1}, \text{ approximately,} \tag{2}$$

with an error which is numerically less than $1\div(n+1)!$.

This result may be applied to various problems. A secretary writes ten letters and addresses their envelopes. If she places the letters in the envelopes at random, what is the probability that no letter goes into its proper envelope? The answer is $e^{-1}=0.36788$ correct to five decimals. Professor Julian Lowell Coolidge of Harvard University has given an amusing application of (2):

"If all the inhabitants of Chicago should meet together in one place and get extremely drunk, and then try to go home by guess-work, the chances that at least one would get back to his own bed are almost two out of three."[2]

The probability that no one would reach his own bed would be e^{-1} with an infinitesimal error. That at least one would reach his own bed and that no one would reach his own bed are mutually exclusive, complementary events so that the sum of their probabilities is one. Hence the probability that at least one Chicagoan reach his own bed is $1-e^{-1}=0.63212$, or almost two chances in three.

Consider now the card game sometimes called by the Germans *renkontrespiel* or encounter game. Each of two players takes a deck of fifty-two cards, shuffles it, and then in unison, one at a time, they turn the cards face up before them. If two cards,

exactly the same, are turned together, there is an encounter, and the game is terminated. Either player may wager that there will or will not be an encounter before all of the cards are turned. The probability of no encounter is e^{-1}. Either deck may be considered as being in the assigned order, and the probability that no card of the second deck is in its proper place in the assigned order, i.e., appears with the same card of the first deck, is e^{-1}. Of course, one person could turn the cards of both decks. Lets us call this a trial. If we make a very great number of trials, the number of trials without encounters divided by the total number of trials is approximately the probability of a non-encounter, or

$$\frac{\text{non-encounters}}{\text{trials}} = e^{-1}, \text{ approximately.} \qquad (3)$$

The greater the number of trials the closer the first member approaches the second. The writer made 562 trials and obtained 208 non-encounters. By (3) this gave $e = 2.7019$, which is correct to only two figures.

It might be of interest to consider the practicality of obtaining e more accurately by this method. Since we are obtaining the value of a ratio by sampling, the standard error (standard deviation) of the result is given by

$$\sqrt{pq \div N}$$

where $p = e^{-1}$ is the expected value of the ratio, or the probability of success in single independent trial, $q = 1 - p$, and N is the number of independent trials.[3] Furthermore, it is very unlikely that the ratio will deviate more than three standard errors from its expected value of e^{-1}. If we wish e correct to five figures, the largest error that we can tolerate in e^{-1} is less than 0.00005. Hence

$$3\sqrt{pq \div N} < 0.00005.$$

This gave $N > (8.37159)10^8$. The writer found that he could make about forty trials per hour. Hence, if an experimenter were to work eight hours per day at this rate, it would require about 7163 years to compute e correct to only five figures by this method.

References

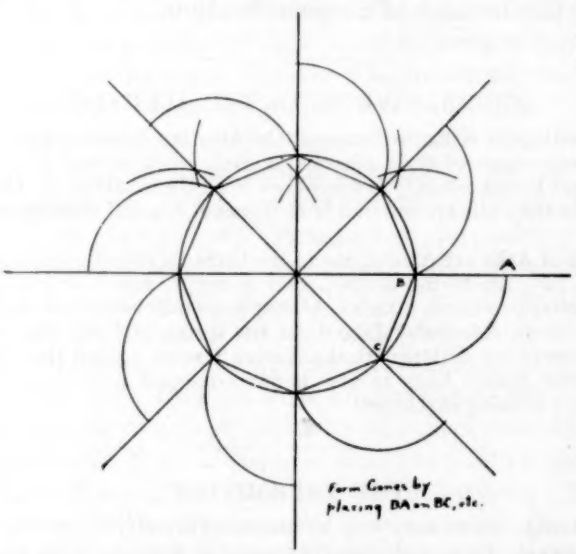
1. Edwards, Joseph: *The Integral Calculus*, Vol. II, p. 825.

2. Coolidge, Julian Lowell: *An Introduction to Mathematical Probability*, p. 25.
3. Yule, G. Udny and Kendall, M. G.: *An Introduction to the Theory of Statistics*, 11th Edition, p. 351.

PUPIL PROJECT: DEMONSTRATION OF THE PRINCIPLE OF THE TURBINE AND THE ANEMOMETER

JOEL J. RHEINS
Corona Junior High School, Corona, New York

This construction can be carried to completion in a two period lesson; or it may be started in one period and finished easily at



home. It furnishes an opportunity to correlate the science and mathematics work of the eighth grade, providing exercise in the manipulation of the compasses toward a worthwhile end. As a review exercise in geometric construction the following elements are present:

(1) Drawing a circle with a given radius.

(2) Drawing the diameter of a given circle; extending the diameter.

(3) Erecting a perpendicular bisector (of the diameter).

(4) Bisecting a right angle.

(5) Inscribing a regular octagon in a circle.

(6) Drawing arcs of a circle, using a given radius, to cut given lines.

The sequence of steps in the construction is obvious from the diagram. If stiff bond paper or oak tag is used, the flaps may be curled over and fastened in any conventional manner; with glue, clips, fasteners, or staples. If a sheetmetal shop is available in the school the exercise may be executed in that medium.

When the rotor has been completed, it may be mounted on a dowel or clothes pin by means of a thumbtack. The breath directed into the cup by means of a straw demonstrates the principle of the turbine. The whole apparatus held horizontally in a breeze demonstrates the principle of the anemometer.

If desired the demonstration can be used also in connection with the construction of a regular hexagon.

SCHOOL SAVINGS IN THE ALEUTIANS

In the village of Atka, halfway out the Aleutian Island chain, the school children elect two of their classmates each week to sell U. S Savings Stamps and Bonds not only in school but to all the inhabitants. The Stamps and Bonds they sell are ordered from Juneau, Alaska, thousands of miles away

Natives of Atka are Aleuts, one of the three races indigenous to Alaska. They are gay, fun-loving people, fond of music, and intensely patriotic. In 1942, after two bomb attacks, Army planes evacuated the entire village to Killisnoo on Admiralty Island. In the spring of 1945, the Army and Navy, cooperating with the Alaska Native Service, rebuilt the village, and brought the Atkans back to new homes equipped with electricity, telephones and washing machines.

THE THERMISTOR

Blood temperatures may now be measured directly in the blood-stream itself by means of a new electric thermometer, announced by the Office of Technical Services, Department of Commerce.

The minute sensitive part of the apparatus, known as a thermistor, is embedded in a glass bead only one twenty-fifth of an inch in diameter. This in turn is encased in the tip of a rubber tube so slender that it can be pushed through a hollow needle inserted into a blood vessel.

From the thermistor a pair of slender wires lead back to a small box containing apparatus for measuring changes in electrical resistance. From these changes, the blood temperature can be determined within a range from 97 to 133 degrees Fahrenheit.

The new blood thermometer was developed during the war by William G. Fastie and Louis F. Drummeter, Jr., under a contract with the Chemical Warfare Service.

SOME FUNDAMENTALS OF BIOLOGY TEACHING

E. LAURENCE PALMER
Cornell University, Ithaca, New York

A successful life concerns itself in part at least with the ability of an individual to so understand other organisms that he can make some of them at least serve his interests. For the last few years, a goodly proportion of human beings have been engaged in trying to drive other human beings from certain portions of the surface of the earth. After one group has driven the other from its authority, it will be necessary somehow that the two groups adjust their differences sufficiently that they can live near each other with reasonable harmony. These necessary readjustments can of course be best effected through mutual understanding and understanding the behavior and reactions of living things is one of the fundamental aims of the biology teacher. It is the purpose of this paper to suggest some ways that seem best to the writer to make a beginning at understanding the behavior of organisms by high school children.

Our common evaluation of a suggestion made to us by others is frequently that it is practical or impractical and usually we delegate those we think impractical to oblivion. Wendell Willkie once recalled Disraeli's definition of the practical man as being the one who practiced the errors of his forebears. I am wondering if some of the procedures we have considered as practical for high school biology teaching are not merely practicing the errors of those who may have taught us. But what is practical anyway? How are we to know what is right and what is wrong? Are we to accept authority of others regarding what we teach and then boast of our over-vaunted political independence? Within the last few months I watched a better than average high school biology teacher present what the teacher contended was a practical lesson for high school students in the field of embryology. A diagram was placed on the board, was erased and changed, and then re-erased and changed again. At no time even after some fifteen minutes had been spent was the diagram correct as representation of the cleavages that took place in the organism under consideration but it seems to the writer even more important that at no time was the student given any overview picture of the life cycle of the organism under study and of the place in that life cycle that was being represented by the diagram on the board. The teacher was show-

ing the pupil something that slightly resembled a diagram that had been seen some time before on a college blackboard. The experience the pupils got came from stimuli that were too remote in time and place to be reliable portrayers of the truth. While the teacher claimed that the pupils were intensely interested in the presentation, I have reason to have some doubts on the subject.

Many of us have prated for years about the value of studying living things in biology in preference to the study of corpses. I do not flatter myself that we have been effective in all of our suggestions and for the purpose of this paper am merely to assume that all biology teachers recognize the superiority of life over death as a vehicle for understanding living things. I admit it is a dangerous assumption but I make it here merely to save time. The purpose of this paper is to suggest some ways in which to study living things intelligently. And even here we are going to further limit ourselves and say that we are interested only in studying effectively the effect of environment on living things, ignoring completely for the time being the effect of heritage on behavior.

Necessarily the scope of the paper must be further limited by saying that it is not a paper on psychology of any organism. If one must be frank, it is a presentation of a few gadgets or tricks in teaching that the writer has found useful in showing children ways in which they can study the effect of environment on living things. Any expecting anything much more profound are entitled to leave at this point.

We are told by some of our trainers of science teachers that we must have specific goals to reach in all that we do. I am not sure that they are right. I agree that we must have a general goal but I am sure that unless I know the value of a specific goal I have no desire to seek it to the exclusion of all others. That is one thing I have liked about nature study. It has not been too specific in its promises. In one of his most recent papers, one of the more persistent critics of the nature study idea tells us, "The young child can be introduced to the idea that animals modify their structure to fit their environment." Again in the same paper he tells us that children can "observe that the decaying vegetation forms natural pockets for the storage of water." I doubt if any child or adult can observe the things here suggested or can safely assume that pockets are formed in the forest floor "for" the storage of water. Of course the pockets are formed

but the "for" part of the statement is ridiculous. Another critic of the nature study philosophy that I have consistently defended tells us in one of his major papers that he has children observe how "insects change to butterflies." Since I am concerned here more with ideas than with whose ideas they may be I shall leave these authors the benefit of anonymity. I mention them merely to show that influential leaders in science education have recommended that children reach conclusions that could not be reached by following the initial "here and now experience" approach which I feel is fundamental. No child who will follow the suggestions here made will ever see an insect like a grasshopper turn into a butterfly nor will he ever find any organism modifying its structure to fit the environment. The only way children could form such generalizations are by accepting the sloppy authority of others. When another leader of this group of critics tells us in print within the year that "the validity of generalizations in science be tested in terms of human experience" I wonder if their major philosophy is not that the scientific method is essentially deductive rather than inductive, and when again the same writer tries to tell me that "there is no essential difference between desirable inservice education for elementary school teachers and that of secondary teachers." I know that he must not have reached that conclusion by inductive reasoning based on first hand experiences with appreciable numbers of these persons.

But let's get down to the subject of this paper. The teacher may say, "Sure, I believe in studying animal behavior first hand. I believe in seeing things and drawing conclusions from them, but what shall I study, what shall I see, and how shall I go about it?" They say, "Certainly, I should like to know the effect of temperature on the behavior of *x* animal and the effect of humidity, light, gravity and other factors of an environment as well but where shall I find the answers? They aren't in the books I have near by." While the *Memoirs of the Ecological Society of America* may contain some of the answers they are not available to most teachers and even if they were it might be more trouble to find the right memoir to meet a situation than to face the situation itself as it arises and where it is.

A few years ago I set out to try to make a simple, cheap bit of laboratory equipment that would yield me reasonably significant answers to why some animals did some things at some times. I realized that to get at the answer I must be able to control some

of the factors that influenced behavior, that I must do this easily, within small areas, and that I must have opportunity to run nearby checks for the sake of comparison. For eighteen years now I have been running a weekly radio program entitled, "This Week in Nature" and I have evolved much of this equipment by working with children before a microphone so that I now have records of how actual children reacted to actual new situations in the development of this equipment. What I and the children said during this development is now on phonograph records and by playing some of these over I have been able to see where the earlier used equipment was faulty and why that on which I am now content to make recommendations has value.

It would take much time if I described the initial equipment that I built in my cellar. It was made of an elaborate series of insulated wooden boxes with glass peek-holes and with complicated trap doors. Suffice it to say that no teacher would be so foolish as I was to try to construct similar equipment and if he did it would probably fall to pieces or fail in some respect the first time it was tried as did my equipment. However, eventually I came to the conclusion that most of the features I needed could be encorporated in a pair of metal-topped glass jars, with a couple of thermometers, an electric heating pad, an ice pack, some cotton and some black paper. I am old enough so that an electric heating pad is appreciated now and then and possibly wild enough so that an ice pack is wise equipment to carry along to a teachers' conference.

The two metal tops of the glass jars were placed back to back over a piece of wood. With a cold chisel a cross was cut through the two tops. One resultant flap was then bent back towards one top and this was alternated for the other flaps so that they were firmly held together with a square hole through their center. Inside each jar, a small thermometer was fastened using adhesive tape. A black paper sleeve was made to fit over either of the bottles and we were now ready to begin to see what we could see. By using the paper sleeve on either bottle it is possible to create quickly an environment in which there is little or no light adjacent to another similar environment in which there is light and with the two environments connected by a passage way through which animals could readily pass. By putting wet cotton in one or the other of the jars the humidity could be changed and by wrapping the useful heating pad or ice pack around the jars the temperature could be raised or lowered. By standing the

jars one above the other provision could be made for studying the vertical movements of animals induced by the climatic changes that took place in my little climate here between my hands. To study the effect of changing temperature, light, humidity and position on an organism small enough and able to go through the opening between the two bottles I now have the necessary equipment. Its cost is negligible and it took me exactly 3 minutes to throw this particular set together from what has always been lying around our house.

Now how have children reacted to this stuff? Let us take a bottle containing some fruit flies such as are found around the fruit in most of our homes today. Before I met a group of children recently I placed these flies in one of my jars. When the children came in I asked them among other things to try to get all of the flies from one jar into the other jar. Among the suggestions that came up were that the bottle with the flies be placed above the bottle without the flies. When this did not work, the suggestion came that the position be reversed. When this too did not work it was obvious that gravity was not a factor which would readily induce these animals to go where I wanted them to go. When this had failed, one youngster proposed striking one bottle to scare the flies into the other. Still another suggested that he might get results by yelling at the insects. Neither procedure being successful one youngster came up with the bright idea that the insects in one bottle could be driven into the other by filling one of them with water. Obviously the desired end could be attained by this procedure but we did not have the water handy and this particular equipment would not yield easily to the necessary modifications to make the demonstration of something that would obviously happen.

Finally, one youngster suggested that one of the bottles be enclosed in the black bag that was lying on the table all of the time. When this was tried success was almost instantaneous. Then they wanted to see if the darkening of one bottle would drive the flies up or down as well as along a horizontal path. You know the result or can see it easily demonstrated. The children had learned that sometimes at least light is one factor that affects the behavior of some fruit flies and that they go towards it no matter in which direction the light source may be. We then tried other insests and found that most of them did not respond or at least did not respond so readily to this factor as did our fruit flies.

For my purposes I have much preferred to get one idea well fixed with a child before introducing another so we repeated this light response with many insects before we tried to introduce another factor. In a latter lesson we did bring in some other things and for this purpose I have found the common cluster fly that is found on almost any classroom window in abundance in the fall an excellent subject with which to experiment. You may know it as the rather slow sluggish fly whose wings are not spread in the alert pose of the common house fly. Somehow laymen seem to think that cluster flies are more likely to "pop" when they are crushed than do house flies and housewives tell us that when crushed they leave a worse grease spot while bald headed men tell us they are more likely to tickle when they settle on a favored perch. One thing is certain. They are common when school opens in the fall and in the spring and why they are to be found inside the windows in such numbers at those particular times of the year makes a reasonable study in animal behavior the essence of which can again be demonstrated by this simple little equipment. Furthermore, we don't have to wait until spring or fall to find the answer if we are able to find the flies with which to experiment. We can find it here, now, not tomorrow, somewhere else.

The cluster fly story is a little more complicated than the fruit fly experiment and may be made as complicated as you like if you wish to follow it up. Instead of light being the only important factor with which to experiment there are at least three besides the fly and this is fortunate because it introduces an appreciation of the fact that we cannot safely form a generalization on the evidence yielded by changing one experimental factor. The three elements of a normal environment with which I have experimented with these flies and with children are the elements of light, of heat and of contact. We like to learn whether conditions can be so set that the flies will go towards light or away from it, whether they will push against contact or avoid it and whether they will seek a place of a different temperature if the light and contact factors are changed. It should be unnecessary here to go into all the details but we can demonstrate rather satisfactorily with this equipment that cluster flies can be made to go away from light by bringing the temperature to a point below 50°F. So if we put some cluster flies on one of these bottles and with the help of the ice pack and the black sleeve create a cool dark place we can see what they

do and from our observations make a generalization. With the help of the heating pad we can quickly change the temperature and see what effect this has on the behavior of our flies. We can introduce a new factor by putting a screen barrier between the two bottles with a mesh large enough for the flies to squeeze through but not large enough for them to pass through readily. Doing this we find that below 50°F. the flies push against contact while above this temperature they avoid it. The complications possible of combining high temperature with or without light and making other combinations and then exposing these flies to these conditions help us understand how these flies react to these conditions. Then knowing these reactions we can rationally interpret why in fall they push against our windows seeking a darkened environment. Once inside our warm houses and warmed they are forced by their nature to seek a lighter region so they collect on the lightest part of their environment our windows.

These are just a few of the simple experiments I have found interesting to children who have had the opportunity of using this equipment in studying the behavior of some common animals. A Polistes wasp or a honey bee in one of the jars shows decidedly interesting reactions which help me understand why they are active at the time of year they are to be found and why they are found where they are found. I can lower the temperature to a point where they are practically inactive and can raise it through optimum temperatures where they seem normally active to still higher temperatures where they cease action. I can count the respiration of some of these insects under the varying climatic conditions I can produce here at will and correlate what I see with what they do. I have not yet tried to introduce the study of the effect of odors or colors on insects under varying climatic conditions but I am sure it would be fruitful since I have found that land snails can be made to go towards food that they cannot see under some conditions.

Possibly some people will think these things too ridiculously simple to warrant consideration by a teacher of science but when I have made a cluster fly do what I want him to do in my house I believe I have a better working knowledge of biology than when I learn from the writings of a science education leader that animals modify their structure to meet changing conditions in environment and I believe that if a child tried to rear a grasshopper or merely experiment with grasshoppers for a

few weeks he will know that he cannot make them turn into butterflies no matter what he read in the books. He has had experiences here and now that make him sensibily sceptical of what he is told happened somewhere else some other time. When some night in my house some of these larger flies that buzz tantalizingly around the bald spot on my head interfere with my work I don't go around wildly swatting at them with a newspaper and knocking the bric-a-brac off the shelf. I happen to know that when the temperature is such that they will fly as they do they react positively towards light. Consequently I get a flashlight, focus it on a piece of white paper that I put against the wall, turn off the other lights. The fly promptly lights on the white spot and I promptly swat him where he will do no harm to bric-a-brac or where he will cause no smear on the wall paper. This is one evidence that I have that in my own home I am master to a degree of some of the animals that live under my roof, some of the time.

But some of you may say why should a biology teacher teach such stuff as how to catch flies that annoy bald spots? Well we are definitely going to be faced with problems infinitely more important than these simple ones and yet what we find in these simple experiments are significant in understanding the more complex ones.

Some of the delightful experiments that were conducted by the late Frank Lutz trying to make cockroaches come out and show themselves at the time when the greatest number of museum patrons passed their show-case home could easily be adapted to use in high school biology classes and yet I have heard of no one making the attempt. Yet in spite of our unwillingness to try to make cockroaches or flies do what we want them to do we as a nation have set ourselves to the task of trying to make whole nations of other human beings live more like we do and believe in the same things we do and react to the authority of others as do we. We may try by law to make them do these things. We surely will try by force but comparatively few people seem to have suggested that we study the animals and try to learn what conditions are likely to produce desirable changes in them and then provide the necessary conditions.

I have spent some months of my life living in the tropics under the flag of the foreign country most nearly like us, the British. I have rebelled always against the necessity of sleeping under a mosquito bar when there were no screens on the rooms.

I have seen no reason why the soup plates had to be turned bottom side up until the soup was served so we might be sure that there were no beetles in the plates before we put the soup there. I know what malaria can do to people because I have seen it at work and yet the very people who suffer with it somehow can see no reason why they should screen their homes to keep out the insects they know carry the disease that robs them of their initiative. To me I can see not the slightest reason why a home in which I might live should not be screened and double screened and yet another man whose not too remote ancestor may have been a next door neighbor of some of my equally remote ancestors just does not think as do I and resents being shown what I think are the errors of his ways. Now I ask you if we have difficulty in showing our allies and close relatives, the British, the advantages of the use of screens that obviously must be helpful in maintaining health, how in the world are we going to show our former enemies, the Germans and the Japanese, the advantages we recognize in using our resources and environment as we have found them to be rational to our needs? How can a nation that has learned to a degree at least to limit its reproductive powers and its treatment of non renewable resources wisely and to live within these limits, how can such a nation show enemy nations the folly of stimulating reproduction to such a point that it becomes necessary that neighboring territory must be taken by force for survival? Our own armor has too many rust spots on it for us to present a united front to the arguments our foes will advance to contradict us. The chicanery of our national conventions for the selection of our national leaders, our ridiculous philosophy that you can buy prosperity, cooperation, allegiance and respect by giving the indigent the rewards that come to the diligent, our blatant belief that any number of freedoms without discipline is superior to discipline without freedom without recognizing the merit of a middle path, makes it difficult for other nations to do little but envy us our wealth for the time being or develop a bad case of the "gi'mes." The gullibility of our leaders is exceeded only by the gullibility of our voters and so we are forced by circumstances to stumble through the difficulties created by our own inefficiencies. Somehow in the whole welter of our population there must arise an element of our population that can command respect and that will fight for convictions based upon demonstrable facts. Possibly the elements of such a section of our nation lie in the group

of students you may teach by this simple equipment to the end that they can make at least one part of their environment do what is wanted by setting the conditions so that they want to do what we want them to do, when they want them to do it here and now, not somewhere else tomorrow or some other time.

Before I would ask youngsters to understand air mass analysis I would want them to understand something of the significance of little climates in their gardens, in their ears and within themselves. Before they can understand that space is vast they should understand that small units of space are significant to what happens in all that vastness. Before they begin to understand that the earth is very old I would like to have them understand the significance of what happens tonight that may influence the color of the leaves by the end of the month, or what happens if a film of oil is allowed to form for a few seconds over the breathing openings of some common things that live near their home. I think microclimates of today are more significant to most of us than are world climates or the climates of the Devonian. I would like people to begin to walk before they try to fly, to be master of a few things before they try to be rulers over many, to reach conclusions inductively before they become too dependent on the deductive procedure, to recognize the merit of disciplined freedom as contrasted either with absolute regimentation or unbridled license, to believe that if they can live wholesomely and well within their environment today they have some right to expect some degree of success tomorrow in a reasonably similar situation.

STOP CHEATING YOUR CHILDREN

Funds for financing education in the U. S. are largely obtained from taxation. But in sparsely settled sections, tax collections are so low that even basic educational needs cannot be met. Therefore, I believe federal aid is necessary.

First, I think legislation should establish a nationwide *minimum* starting salary for young teachers of, say, $2400 a year—varying only according to the cost of living in different sections of the country.

Second, I think that every teacher should be guaranteed a *minimum* raise of $100 a year, thus permitting him to earn at least $5000 a year during his useful career. Remember, I am speaking of a minimum *guarantee*. If a teacher isn't worth that, he isn't worth having as an instructor for our youngsters.

Third, in those areas of the country where local and state funds are not sufficient to pay teachers at these rates, federal subsidies must be provided to make up the deficit.—From an article by Charles Harris in the October *Coronet*.

DIFFICULT HIGH SCHOOL CHEMISTRY

B. CLIFFORD HENDRICKS
The University of Nebraska, Lincoln, Nebraska

Any experienced teacher of high school chemistry can readily enumerate certain phases of chemistry which are mastered by his pupils only after much more than usual effort. Pupils in the lower quartile of the group are very likely not to succeed with these topics at all. Some teachers, for this reason, question their inclusion in the course.

Stated in the fewest possible words these topics are: 1, the quantitative relations of the substances involved in the transformations of matter; 2, the theories which attempt to describe mechanical models for picturing matter and its changes; and, 3, the symbolism which seeks, in the briefest possible space, to express these relationships.

The discerning teacher knows that, of the three, number one is the most fundamental. There was a chemistry long before theories were improvised in order to organize it. It is quite possible to present chemistry without its symbolism. But chemistry is devoid of much of its right to be called a science if its measuring units are banished from its laboratories.

The trained teacher also knows that without the certainty of the quantitative relation there is no fact basis for the assumptions advanced in the theories of chemistry. For instance, without an equivalent weight, where get an atomic weight? With no certainty of an electro-chemical equivalent how define an ion or an electron?

Symbols are very generally considered as representative of theoretical entities. Zn is thought to represent an atom of zinc, or H^+ as a charged or electrified equivalent of hydrogen. So it is evident that should a teacher elect to retain symbolism in the course but to delete theory the symbolism could, with but little difficulty, be related directly to the quantitative concepts of the science.

Just how to teach these quantitative relationships in an interesting manner is one of the major difficulties of the teacher of high school chemistry. To attempt it by quantitative experiments performed by the students in the laboratory would not receive the approval of most experienced teachers. Their objection is that the average high school student is so confused by the laboratory balance and the manipulations in such experiments

that he entirely loses sight of the experiments' objectives. There are then two alternatives if the laboratory approach for this topic is to be used; either teacher demonstrations or demonstrations by the high-quartile students of the class. Fortunate are the pupils whose teacher brings to these demonstrations historic illumination from the lives of Dalton, or Lavoisier, or Berzelius to stimulate interest. Then, too, the wise teacher always tries out such demonstration experiments at some time before use in class or laboratory to make sure of their outcomes.

Quantitative experiments demand quantitative expression. Numbers, for many students, seem to "set-off" their defense mechanisms. Such students have probably drifted through arithmetic, algebra, and geometry, considering mathematics something to be remembered rather than something to be understood. Proportion, for instance, to them has little or no relation to their experience. If they use proportion to describe quantitative relations in chemistry they express a new, not-well-understood, concept by a foreign little-understood language. Two unknowns in an equation make it more difficult of solution. Good teachers then would try to eliminate one of these unknowns, the proportion perhaps, by using a type of arithmetic that has meaning from use in the pupil's experience. The arithmetic which the student uses in his shopping certainly would qualify in that regard. An examination of the different types of arithmetic problems encountered in chenistry reveals that all can, without exception, be solved by such simple "shop-arithmetic."

If the theories of chemistry are to be included in the curriculum the teacher should remember that, generally, a theory consists of a series of assumptions made in an attempt to relate facts which seem to have little relationship without the theory. The laws of definite composition, multiple proportions and equivalent weights have no relationship apparent until the assumptions of the atomic theory postulate atomic weight as implied in all three laws. If this conception of a theory is accepted it is a very poor teaching procedure to attempt to present the theory before the student has had an acquaintance with the facts which it is to relate. It is obvious that the student under such teaching would see no need for the theory. He might well raise the question, "Of what use is it?"

The ionic theory affords an excellent illustration of what has just been said. By the time the class has reached that point in their course the electrolysis of water has been demonstrated, and

the displacement of hydrogen by a metal has been performed, the conductivity of acids, bases and salts may have been exhibited. Additional pertinent facts may be suggested by demonstrating; the electro-plating of copper and the color change of copper bromide by water dilution. Superficial observation reveals no relationship between the electrical decomposition of water, the plating out of copper, the driving of hydrogen from an acid, the conductivity of lye solutions or the colors of solutions. Yet how readily the assumptions made in the ionic theory reduce the explanations of all these phenomena to a description of the properties of ions!

Again the fact of incomplete reactions, noted many times during the first semester by the student under proper teacher guidance, should challenge the thinking student to look for a generalization. Thus the notion of reversible reaction comes in response to a felt need. The *control* of such reactions, another interesting phase of chemistry, cannot receive much attention without the possibility of *equilibrium* becoming significant. Attention to industrial processes readily raises the question of profitable yields. From this practical situation these aspects of chemistry may be developed in a truly psychological manner. The problem of their inclusion in the course is solved by the limits of the student's capacity for interest in such activities. Some teachers may at this point raise the question of time limits of the course. In answer, the relative value of these principles of chemistry to the student's mental growth compared with a catalog of the properties of metals should be considered.

Another generalization of chemistry which has something of the same sort of intriguing interest as a cross-word puzzle is the periodic table of the elements. Here again it should be patent to any thinking teacher that facts must precede generalization. This would place a consideration of this topic near the close of the course or at most not earlier than when a reasonable acquaintance with two or more families of elements has been made. The chief bid for the pupil's attention to this principle is probably that it provides a means of learning the most chemistry in the least time.

Next to "mathematics" probably more failing students blame "formulas and equations" for their delinquency than any other part of chemistry. Teachers generally are aware that, among other classifications, students may be grouped into idea-minded and thing-minded individuals. For idea-minded students the

symbolism of chemistry is one of its attractions. To teach chemistry without its symbolism would be a distinct disappointment to them. The second group, however, get relationships only when they involve concrete, material objects and are likely to be disturbed when asked to express such relationships by symbols. For them just as x, y, z relationships in algebra were something to be remembered rather than to be understood, so H_2, Na, and OH^- for these students are memory tasks rather than activities of understanding. If the teacher is conscious of these traits of her students she will make sure that the idea as well as the symbol is fixed by drill.

An equation expresses a fact. Many teachers need to be reminded that the learning order is first the fact, second, the expression. For this reason some teachers require that simple word statements always precede the symbolized expression, the equations, for the first few months. Likewise many teachers prefer to defer use of formulas until their quantitative, weight and volume meanings, as well as qualitative meanings may be taught. They feel that such a plan helps to demand an understanding rather than a mere remembering of them.

A moment's reflection easily makes apparent the reason so many students find difficulty with valence. Valence is a relationship between theoretical units, atoms, represented by symbolic representation of another theoretical unit, a molecule. Nowhere in all of this is there a single concrete entity capable of impressing one or more of our senses. The thing-minded students are very likely to drop out of the picture at this point in the course.

After all is said regarding symbolism there is still some justification of the criticism that symbols, formulas and equations are a technical language which has no future usefulness except to those students who continue in college chemistry. Since such students are but a small per cent of the total taking high school chemistry there is no justice in demanding of the ninety and nine that which only the one needs. Even granting symbolism as a required part of the course some teachers need to be reminded that it is only a *part* of the course and that it is possible to have a very useful understanding of chemistry without a mastery of its symbolism.

However, if a mastery of symbolism is expected of the student it is unfair to deny him valence as an aid to *remembering formulas*. Further, if he is expected to balance oxidation-reduction

equations of any degree of complexity by the valence-change method, a knowledge of valence is a prerequisite. So in high schools which have distinct college-preparatory courses the teachers are very likely to require a mastery of this phase of chemistry's symbolism.

It appears, from the foregoing, that the difficulties of chemistry are largely centered around the ability to generalize and ability to symbolize. In both abilities the element of abstraction is important and perhaps the disturbing factor. Any student of school age mentality can abstract to some degree. In the teaching of chemistry it may be that a grouping of students relative to their ability to abstract is the effective manner of solving the difficulty. By so doing, the student, who is so slow in this regard as to lose interest before mastery is obtained, may have less of that part of chemistry required of him. Truly it would be poor practice to deny to those capable of enjoying it the training this phase of chemistry offers just because some of their classmates handle it with ill success.

A COORDINATOR OF SCIENTIFIC ACTIVITIES APPOINTED AT THE GEORGE WASHINGTON UNIVERSITY

To further development of scientific research at The George Washington University officials have announced appointment of a Coordinator of Scientific Activities, Dr. Benjamin Douglass Van Evera, professor of chemistry and executive officer of the chemistry department.

Dr. Van Evera will work as an associate with Dr. Robert Whitney Bolwell, chairman of the University's Graduate Council which was established in 1930 to offer a program of advanced study and research leading only to the degree of Doctor of Philosophy.

With the appointment of Dr. Van Evera, the University expects to extend its services more widely beyond the walls of the institution. The new coordinator will assist graduate students and faculty members in scientific research projects and studies and will encourage combinations of and collaboration on various research problems. He also will serve a in liaison capacity between the science departments of the University and various Government and private institutions, laboratories, and agencies.

This work would include arranging contracts with groups that want the University to perform specific research projects and arranging conditions under which faculty members may serve as consultants.

The new director's office also will collaborate with the science departments concerning the securing of supplies and work out other group problems in research.

Fields of research in science authorized by the Graduate Council at The George Washington University include bacteriology, biochemistry, botany, chemistry, mathematics, pharmacology, physics, physiology, psychiatry, and zoology.

THE GRAPHICAL CONSTRUCTION OF IMAGES FOR LENSES AND MIRRORS

GORDON MILLS
The University of Texas, Austin 12, Texas

The problem of learning the fundamental properties of lenses and mirrors is made irksome for many beginning students by the difficulty of correlating the several rules and equations for location, size, and kind of image into a clear concept of the physical phenomena involved. The method of treating the graphical construction of images for mirrors and thin lenses which is described below has proved to be of value in helping the student to make that correlation.

The principle on which this method is based is simply the elimination of all variable elements but one from a given con-

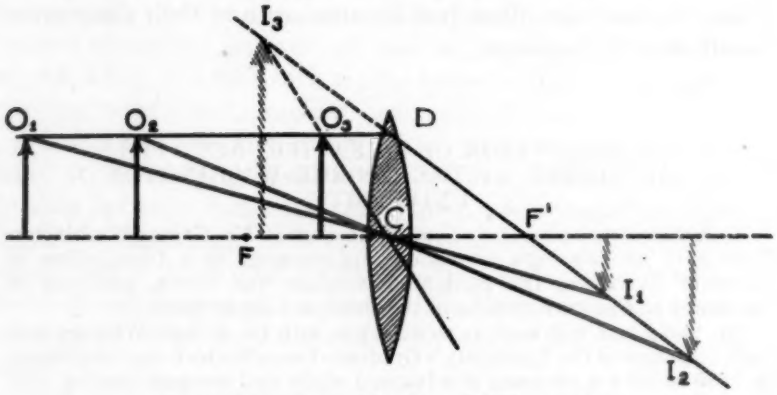


FIG. 1. Images formed by a double convex lens.
O_1, O_2, O_3: object
I_1, I_2, I_3: image

struction, followed by a demonstration of what happens as that element is varied. The construction is entirely conventional.

Consider the case of a thin convex lens, as shown in Fig. 1. The head of the image is located by the use of only two "rays," and the object is shown at three different distances, with the corresponding images. Of these two rays, the construction of the one that is parallel to the principal axis is always the same, regardless of the object distance, with the single qualification that line DI_2 must be projected "backwards" for the construction of a virtual image. Conversely, the ray that passes through the optical center of the lens is not, in the same sense, fixed. It may

be thought of as turning in a clockwise direction about the optical center of the lens, as on a pivot, as the object approaches the lens. Thus, when the student has been shown this fact, it becomes fairly easy for him to form a correct mental picture of the image for any given position of the object, by visualizing the intersections of the "moving" with the "fixed" ray. Figure 1 is intended to suggest the "pivoting" of the ray *OI* (or *OC*) as the object approaches the lens through positions O_1, O_2, and O_3.

It is the idea of the "pivoting" of the one ray about a fixed point that should be given emphasis. Very often graphical construction is first presented to students in terms of the two rays (together with the principal axis) that are shown here, and occasionally it is pointed out that only one of the two rays is "variable." However, it is not until the student has caught the idea of the ray pivoting about a fixed point that he has a concept to which every specific case can easily be related.

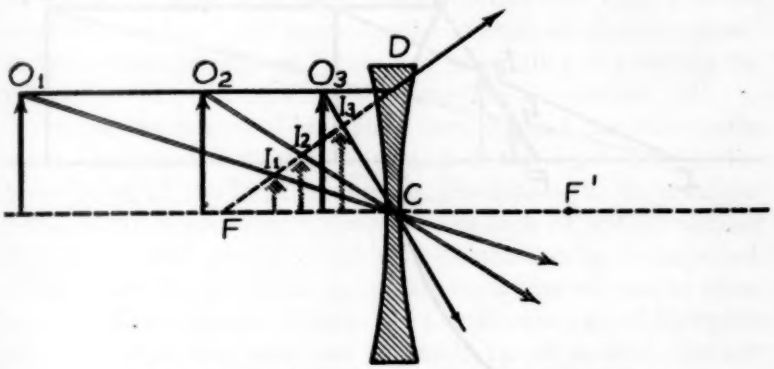


FIG. 2. Images formed by a double concave lens.

Figure 2 illustrates the application of this treatment to a thin concave lens. The same two rays are used as for the convex lens, and the fact that here only virtual images need be shown makes the situation even simpler.

The same method may also be employed for convex mirrors, as illustrated in Fig. 3. Here again a ray (*OAF*) parallel to the principal axis serves as the fixed ray. The moving ray (*OC*) is one which passes through the center of curvature of the mirror: it may be thought of as turning about the center of curvature in a counterclockwise direction as the object approaches the mirror.

It is obvious that this principle can be applied also to the construction of images for a concave mirror. However, it is of

doubtful value in this case because of the complications that arise as the object goes from outside to inside of the principal focus.

The use of a simple mechanical model is helpful in demonstrating the method. This model need consist only of a piece of cardboard or plywood, on which the lens or mirror and its fixed rays have been clearly drawn, and a slender wooden or metal rod pivoted at the optical center of the lens, or at the center of curvature of the mirror, to represent the moving ray. More elaborate models might make use of movable "objects" and "images," perhaps with a suitable system of linkages; but they would seem scarcely worth the effort.

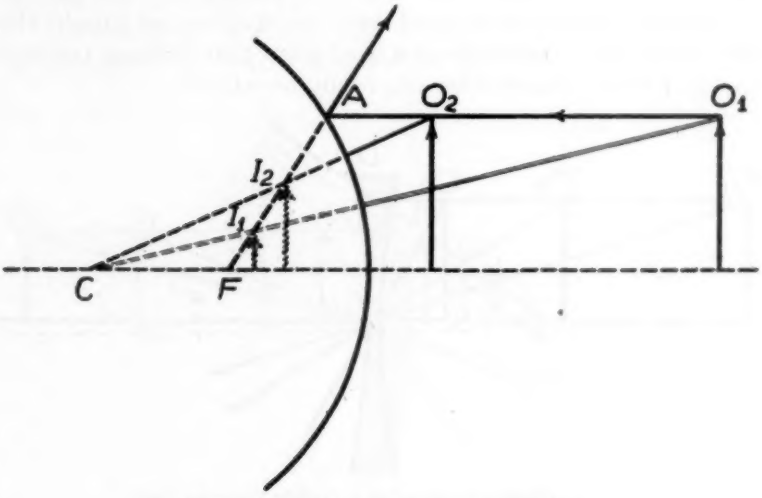


FIG. 3. Images formed by convex mirror.

In conclusion, perhaps it should be said that this is not a recommendation that the student be taught to use only the two rays mentioned above. This method of treating the graphical construction of images—if it can properly be called a method—serves best as a supplement to conventional methods. It is a pedagogical trick; but it does seem effective in evoking a sound understanding of basic principles.

Fire-fighting equipment, for use when airplanes crash, is mounted on a jeep and contains, in addition to ordinary tools, a powered circular saw and a powered push-bull back saw, both for use in cutting into the metal fuselage. A powerful winch operates a grappling hook.

THE BIOLOGIST AND THE COMING WORLD ORDER

EDWARD C. COLIN
Chicago Teachers College, Chicago, Illinois

Biologists, including psychologists and anthropologists, have a unique contribution to make to the development of a more efficient world order. They have at hand a large body of proved fact and principle which may be applied to the human species. The biologist has faith in the possibility of the further genetic progress of mankind. To him, no enterprise is more worthy of his labors than the promotion of that progress. He realizes that the process of evolution does not insure the continued perfection of adaptation of any species—to say nothing of the indefinite survival of the species—and he is therefore not content merely to be hopeful; he must also be industrious. Only with the assistance of man's newly-acquired and most distinctive characteristic, *intelligence*, does he see any possibility of avoiding the extinction which in time tends to overtake all species.

Among the admitted biological facts we find that man is the most numerous, the most varied, and the most widely distributed of all the larger mammals. He is also the most migratory. There is no good evidence of any lack of fertility among the many racial groups of which the human species is composed. This, in fact, is one of the reasons for regarding all men as members of a single species. Today only a small minority of biologists prefer to consider mankind as made up of several distinct species; this they do on the basis of morphological differences among the various human stocks.

Whether we regard man as constituting one species or as several is of more than academic interest. In nature each species is utterly self-centered in that no species lives for the sake of another nor hesitates to use another for food or otherwise as its interest and convenience dictate. Man is no exception. If men belonged to different species, slavery or any other form of domination could be excused. In Darwin's time many biologists, including the famous zoologist Louis Agassiz of Harvard, took the view that the Negro and the Caucasian were distinct species. Darwin, from his own extensive knowledge and his thorough analysis of the data, concluded that all men should be included under one species. He relied not only on the mutual fertility of

all racial crosses so far as known and on the intergradations among races, but also on the many fundamental similarities, both physical and mental, in all races. Darwin's view was supported by the able biologist and student of man Thomas H. Huxley; and this is the view generally accepted today by anthropologists and geneticists. The major divisions of mankind—Negroids, Australoids, Caucasoids, and Mongoloids—are geographical races or subspecies as these terms are used synonymously in mammalian taxonomy. Taken together they comprehend an immense store of genetic variability which offers great possibilities of future progressive evolution of the species. An omnipotent director of evolution—if such could be imagined—would not lightly destroy any of this genetic material until its possible contributions had been thoroughly tested.

Admitted also is the fact of the great reproductive capacity of human kind and the resulting tendency of the population to increase in geometric ratio. Estimates indicate that during the past three centuries our numbers have multiplied five fold, from about 400,000,000 to more than 2,000,000,000. Although the rate of increase is slowing down in many parts of the world and has even reached a static level in some places, there are large areas in which it remains so high that it constitutes one of the acute social and political problems of our time. In India, for example, the census figures show an increase of more than 50,000,000 (a number larger than the entire population of Great Britain) during the decade 1931–1941. By this time India no doubt has a population of more than 400,000,000, equal to the population of the world in the time of Shakespeare.

Man's great reproductive potentiality makes inevitable some form of check on his natural increase, because there is, obviously, a limit to the numbers able to exist on earth—to say nothing of their ability to exist in comfort. The old checks of famine, pestilence, and (we hope) war are gradually yielding to the advances of modern science. Among the most highly industrialized countries a new check, the voluntary limitation of family size, has become paramount in recent decades. Since many groups have thus taken the regulation of their numbers into their own hands and since others will no doubt do so in future, it is incumbent on man to find a rational solution of the problem of optimum numbers. The answer to this question will depend in part upon our ability to produce food in larger quantities and of better quality. Here the plant breeder, the animal

breeder, and the theoretical geneticist will continue to be of special value to society.

The population question is not merely one of numbers. Of equal importance is the matter of quality. What, if anything, can be done consciously to improve the quality of the individuals of our own species? A scientific answer requires a knowledge of human genetics and a broad understanding of the principles of inbreeding and crossbreeding and of selection. A growing mass of information is available on the manner of transmission of many human traits—good, bad, and indifferent. Much is known about the roles of heredity and environment as conditioning factors in the development of specific differences among men. Verified theories have been developed on the effects of inbreeding and crossbreeding in mammals. So far as these theories have been tested on man they are found to apply to him as well as to other mammals. Regarding the biological effects of race crossing —a question on which nearly everyone has a conviction, though commonly founded on emotion rather than on reason—the biologist can give valuable advice to the citizen, the legislator, and the statesman. An understanding of the problem will help in the solution of such difficult political questions as immigration.

Among the major evolutionary factors effecting specific changes in organisms are hereditary change, or mutation, and selection. In man at present it is practicable to make use only of such mutations as occur spontaneously. A speeding up of the rate of mutation in plants and animals through their exposure to penetrating radiations in the form of x-rays and neutrons has been shown to increase greatly the number of injurious mutations. A beneficial mutation is a rare occurrence in nature and no doubt is proportionately rare under treatment. No method has been discovered for controlling the direction of mutation, and so far no practical application of an artificially increased rate of mutation in mammals has been made. The problem must be left for future investigation. On the other hand, by means of selection man has been able to do wonders in the modification of his domesticated animals.

Respecting man, two types of selection are always at work: these are natural selection and conscious selection. The operation of natural selection in man is widely misunderstood. To some people it means merely the law of tooth and fang, a struggle to the death among members of the species. Such a struggle

is, however, a rare expression of the principle of natural selection in species other than man. Selection of a more subtle and continuous nature seems always to be effective. For example, selection tends to make species and races more resistant to invading parasites of all sorts by the elimination of the more susceptible individuals and the preservation of those possessing mutations conditioning high resistance. Moreover, natural selection is always actively weeding out hereditary gross defectives and individuals with a tendency to the early development of degenerative conditions. So far as we can see, the human organism will never be entirely free from the attacks of parasites and our species will always produce a certain proportion of malformed individuals. With respect to parasites as well as malformations a great deal, of course, can be done to reduce further their frequency and to mitigate their effects.

Conscious and voluntary selection in man offers possibilities which have scarcely been tapped. As to the efficacy of this factor the biologist is usually much more optomistic than is the social scientist. Biologists are not likely to fall into the error of asserting, as does a recent writer of an important book on human population,[1] that aside from a small percentage of our population which cannot be identified with much assurance, our people have sound heredity. Just what is meant by "sound heredity" is not explained; but experience indicates that every human family, and perhaps every individual, has at least one hereditary weakness, defect, or susceptibility. Soundness, therefore, is clearly a relative term. To imply that no concern need be felt for the genetic improvement of the human population is misleading and harmful.

The foregoing problems are all of world-wide importance. Their importance is secondary, however, to the more basic question of the future political organization of the world. Shall the trend toward the integration of mankind into larger and larger political units, as observed during historic times, be arrested at the present stage, leaving each nation largely a law unto itself, with the certainty of periodic and violent conflicts? Or shall the process of organization go on to its logical conclusion until all the members of our species come to owe allegiance to one supreme organization? On this question there is no unanimity of opinion among biologists any more than there is among people in general. From various indications, however, it

[1] *Plenty of People* by Warren S. Thompson, The Jaques Cattell Press, 1944.

seems that the majority of enlightened minds among all classes of men see nothing impossible or inimical in taking the final step toward integration. They see no reason why continued progress biologically as well as socially may not go on in the absence of armed conflict among various groups of men. Some are willing to admit that war may have had a selective function in the past, but they do not agree that because a thing has always been it must always be. Evolution teaches that the opposite is true. They demand to be shown some gain resulting from war that could not logically accrue through other means. Balanced against any possible benefit from war must be its present largely indiscriminate, unpredictable, and increasing destructiveness. Mankind, it would seem, stands to risk less through the experiment of organizing into a single world government of limited powers than through allowing the species to drift in the present sea of international anarchy.

Political questions are intimately tied up with our ideals. It is clear that men cannot yet agree on ideals respecting economic and political systems or on religion. Attempts at further integration should therefore recognize this fact and should allow for autonomy within such spheres—wherever autonomy is not incompatible with the general welfare. We cannot agree—and there is need that we should agree—in our preferences concerning human physical characteristics like skin color, hair form, facial features, body proportions, and so on, But surely we can agree on the desirability of a progressive civilization (though not on its definition) and on the need for improvement in the health and intelligence of the human population as well as in the environment in which people live. Scientists, at least, will all agree to the great benefits flowing from a cultivation of the scientific attitude, as eloquently expressed by the great English physician and physiologist William Harvey a little more than three centuries ago:

> True Philosophers teach us in our course of philosophy as sedulously to avoid the fables of the poets and the fancies of the vulgar, as the false conclusions of the sceptics. And then the studious, and good, and true, never suffer their minds to be warped by the passions of hatred and envy, which unfit men duly to weigh the arguments that are advanced in behalf of truth, or to appreciate the proposition that is even fairly demonstrated; neither do they think it unworthy of them to change their opinion if truth and undoubted demonstration require them so to do; nor do they esteem it discreditable to desert error, though sanctioned by the highest antiquity: for they know full well that to err, to be deceived, is human; that many things are discovered by accident, and that many may be learned indif-

ferently from any quarter, by an old man from a youth, by a person of understanding from one of inferior capacity.—*Anatomical Studies on the Motion of the Heart and Blood*, 1628.

M.I.T. PRESIDENT CITES NEED FOR ENGINEERS

Future demand for engineering graduates will be more than twice as great as before the war, according to Karl T. Compton, president of Massachusetts Institute of Technology.

"Despite increased military and civilian demands during the war, the number graduating from engineering schools," he declared, "has declined steadily to a low this year of less than 7,000, including those in Army and Navy sponsored programs. This compares with a normal complement early in the war of almost 15,000."

Dr. Compton pointed out that during the war virtually all of the technical talent focused its attention on the development of equipment and techniques for the single purpose of winning the war.

"Even though a great deal of this research will have peacetime application, we have undoubtedly lost ground in our constructive efforts constantly to improve the standard of living. Further, we have drawn heavily on our reservoir of fundamental scientific knowledge because most of the war research concerned the *application* of science and any basic research was incidental to the major task. We must therefore promptly replenish the supply of the 'raw materials' of engineering and science."

The M.I.T. president added that during the war almost every company producing war equipment was dependent in some way on technical manpower. "That this trend will continue in peacetime is borne out strikingly by a survey recently conducted among 125 companies throughout the United States by a committee of the American Society of Engineering Education. The results indicate that the future annual demand for engineering graduates will be more than twice as great as before the war."

In conclusion, Dr. Compton declared that the future for the young man in engineering or science is "indeed bright"; that it presents "a challenge and an opportunity that we should not and cannot let pass.

"Educators and industrialists alike must do everything possible to encourage students at the secondary school level to study basic sciences and to develop in the students an interest in a future career in one of the technical fields."

He commended industrial companies for their efforts in stimulating interest through science awards and scholarships given each year to promising young men and women and cited the Bausch & Lomb Honorary Science Award Medal and Science Scholarships, and the Westinghouse Talent Search, "as two examples of awards which annually attract nationwide attention."

ACCIDENTS CHIEF KILLER OF SCHOOL BOYS, GIRLS

Accidents constitute the chief killer of school children in the United States, taking the lives of about 6,500 each year.

Although the number of boys and girls dying from accidents has declined markedly in the last few decades, the reduction has not kept pace with the decline in deaths from disease.

A CHEMIST LOOKS AT THE MANUFACTURE AND CONTROL OF PHARMACEUTICALS[1]

J. RUSSELL BRIGHT
Wayne University, Detroit, Michigan

I wish to speak to you today as a chemist. However, I shall talk about medicines and drugs. We Detroiters claim that our city is the pharmaceutical center of the world. For example, the following list of Detroit companies which manufacture drugs and pharmaceuticals is an impressive one: Difco Laboratories, Frederick Stearns and Company Division of Sterling Products, Gelatin Products Corporation, Heyden Chemical Company, and Parke, Davis and Company. Some of these you know about already. I feel certain that most of you have seen and used the products of all of them.

For the purposes of our discussion the manufacturing phase of the pharmaceutical industry may be divided into four categories:

1. Personnel
2. Buildings and equipment (including laboratories)
3. Raw materials
4. The finished product

We shall discuss each of the above items and then divert our attention to some of the very recent pharmaceutical developments—during 1945 and 1946.

First let me tell you a story.[2]

"In the City of Bagdad lived Hakeem, the Wise One, and many people went to him for counsel, which he gave freely to all, asking nothing in return.

"There came to him a young man, who had spent much but got little, and said: 'Tell me, Wise One, what shall I do to receive the most for that which I spend?'

"Hakeem answered, 'A thing that is bought or sold has no value unless it contains that which cannot be bought or sold. Look for the Priceless Ingredient.'

"But, what is this Priceless Ingredient?' asked the young man.

"Spoke then the Wise One: 'My son, the Priceless Ingredient of every product in the market-place is the Honor and Integrity of him who makes it. Consider his name before you buy'."

PERSONNEL

The above story indicates the desirability of well trained,

[1] An address given before the CASMT Biology Section Meeting at Detroit, Michigan, on November 29, 1946.

[2] "Copyright 1922 by E. R. Squibb and Sons."

alert, honest, and trustworthy employees, who, in their right, must receive for their services compensation which permits a decent standard of living. Actually, labor and management do "depend on each other." In addition to the usual supervision of production departments, it is common practice in the drug industry to superimpose a system of process "control inspectors." These inspectors need sufficient technical training and experience with the operations being checked, plus enough common sense to make the required checks on identity of material and weight checks, followed by the inspector's approval showing that all detailed directions have been carefully followed.

Buildings and Equipment

One fundamental principle of modern industry is to control the quality of products during manufacture instead of waiting until the products are made and then subjecting them to rigid inspection. During all stages the Control Laboratory plays a most important part.

Quality Control as well as Cost Control means use of good equipment and machinery. In the process industries it is necessary to use accurate scales. Automatic scales, for example, have reduced substantially the time and labor required for weighing. As a result of recent advances[3] the chances for human error have been practically eliminated. In many processes the yield and quality of the final products depend upon very exact weighing of the raw materials. Weight Control, therefore, is possibly the most strategic operation involved.

It is an elementary principle of process and product control that "the finer the production controls, the surer a manufacturer can be of his products."

In so far as the buildings, etc. are concerned, Quality Control implies *sanitary control* of the premises which requires:

1. Pest elimination and control
2. Good housekeeping
3. Use of cleaning and sanitizing agents

Since many of the medicines and drugs are intended for internal use, it is important to emphasize at this point that a very minimum amount of filth, dirt, etc. is ever found in pharmaceutical products due to the vigilance of the government inspectors from the Food and Drug Administration. This reminds me of the story of the Negro preacher who complimented a parishioner

[3] Considine, D. M., *Chem. & Met. Eng.*, *53*, April, 1946, p. 125.

on his fine garden. "I'm glad to see," he said, "what you have grown here with the aid of the Lord." "Thank you," said the gratified gardener, "but you shoulda seen it when de Lawd was takin' care of it Hisself."

Raw Materials and Finished Products

These two categories may well be discussed together. Today, manufacturers of packaged medicines test every raw material to determine that it meets very rigid specifications, and inspect every step of all manufacturing processes constantly to make certain that nothing occurs to lower the quality of the finished product. Standards of assay, methods of control, precision and accuracy of measurements, degree of cleanliness, and purity are much better than anything ever dreamed of a decade or two ago.

Mass production is only possible, satisfactorily, when the finished product is capable of accurate control. The technique of mass production in the field of pharmaceuticals has made differences in products small, but variation has not been eliminated and the necessity for detecting small changes is greater than it ever was due to the large number of units involved. Statistical interpretation is the mathematically sound method for establishing controls and tolerances. The application of statistics to analytical data has been summarized in Calco Technical Bulletin No. 773 as follows:

"1. Deciding what control tests are worthwhile and what ones can be eliminated.

"2. Help in establishing tolerances and balancing the sensitivity of the analytical method to the tolerances. Matching production goals to specifications.

"3. Help in establishing sampling procedures. Determination of homogeneity. Deciding how many samples to take. What size sample should be taken.

"4. Determine how good analyses are. What differences are significant. What data are gross errors. How many more tests are needed to get a desired precision."

The consuming public is learning to recognize that there is no substitute for quality. As teachers perhaps we can help all consumers to understand that the responsibility for making a quality product must at all times be placed at the door of the manufacturer. As consumers, we should rejoice that various federal agencies, e.g., F.D.A., F.T.C., etc., really have more power than formerly. The manufacturer of drugs like the manu-

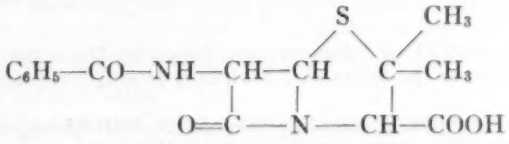
facturer of automobiles recognizes that: "quality must be built into a product. It cannot be inspected into it."[4]

Recent Developments in Pharmaceuticals

Since my listeners are biology teachers, I might just as well have called this section: "Some Recent Advances in Biological Science." Many new drugs have been placed on the market or made available for clinical trial during the past few years. Naturally, many more are still in the experimental stage. The results, so interesting and beneficial to all of us, are the combined efforts of the chemists, biologists, pharmacologists, clinicians, physicians, and many others.

The trend in modern medicinals is indicated by the following list: Antibiotics, Antimalarials, Antispasmodics, Bal, Influenza Virus Vaccine, Digitoxin, Curare, Prostigmine, Sulfathalidine, Folic Acid, Promin, Salicylates, DFP, DDT, Amino Acids, Radioactive Isotopes, etc.

Most of us have probably heard and read more about penicillin and streptomycin than any other microbiotics. The early commercially available penicillin was yellow, but the pure crystalline material now available is white. Actually, at least four types of penicillin were present in certain of the commercial products. These penicillins (F, G, K, and X) differed slightly in the side chain attached to their common chemical nuclear structure. In penicillin G, for example, this side chain is a benzyl group, viz:



Penicillin X has a para-hydroxybenzyl group while F and K are both found to be aliphatic, being characterized by the Δ^2-pentenyl and n-heptyl groups respectively. Du Vigneaud has reported[5] the synthesis of penicillin.

Kraft[6] has reported recently that the Food and Drug Administration will soon authorize manufacturers to label as penicillin "G" crystalline penicillin containing 90 per cent or more of

[4] Manuele, Joseph, *Elementary Principles of Quality Control*, Westinghouse Electric and Manufacturing Company.

[5] du Vigneaud, et. al., *Science*, November 8, 1946, p. 431.

[6] Kraft, Arthur, *The Journal of Commerce*, October 31, 1946, p. 9.

"G" type. This has been made possible through a new method of assay developed by F.D.A. As a result of a two-day conference held a month ago in Washington, the following penicillin rules are expected to be announced soon:

"1. The content of penicillin 'K' in all but ointment and other preparations for surface application will be limited to no more than 30 per cent of the total.

"2. Penicillin 'G' preparations must have a potency of no less than 1,500 units per milligram. Preparations now on the market range from 1,300 units per milligram and upward in potency.

"3. Manufacturers must state that all types of penicillin, except crystalline, retain stability for only seven days in solution. They must state that crystalline penicillin will retain its stability in solution for three days.

"4. Manufacturers of oil, wax and tablet preparations will no longer be required to furnish a refrigeration statement. However, they must provide a statement of the expiration date, 12 months for amorphous forms and 18 months for crystalline.

"5. The time period for the test of crystalline penicillin, whereby the preparation is kept at 100 degrees centigrade, is reduced from six to four days. After four days the penicillin must retain at least 90 per cent of its potency at this extreme heat in order to pass the test.

"6. Manufacturers will be permitted to use either type one or type two glass bottles for injectable type penicillin. At present, only type one glass has been permitted by FDA. Type two, inferior glass, is no longer considered harmful to penicillin."

The above information has been presented to show you the effect of government control on the manufacture and release of new drugs.

Streptomycin is an antibiotic of low toxicity obtained from cultures of a strain of *Actinomyces griseus*. Chemically it has been found to be a strong base. The hydroxylated base, which has been designated streptidine, is attached by a glucosidic linkage to streptobiosamine, a disaccharide-like molecule containing nitrogen.

The danger of microorganisms developing resistance to penicillin and streptomycin has recently been very much emphasized. Physicians have therefore been instructed to use large doses. The production of these antibiotics has recently been increased. For example the price of streptomycin has dropped from $20 per gram to $10 per gram.

Similarly, we could go into detail regarding the other modern medicinals listed in the second paragraph of this section. However, we shall refer you to several good articles on this subject.[7]

[7] (a) Volwiler and MacCorquodale, "Some Pharmaceutical Developments in 1945." *Chem. & Eng. News, 24,* 346 (1946).

(b) "Advances in Biological Science," *J. Am. Pharm. Assoc.*, Pract. Ed. *7,* 212 (1946).

(c) Holland "Trends in Modern Medicinals" *Am. Journ. Pharm. 118,* 192 (1946).

ENTHUSIASM IN ELEMENTARY SCIENCE TEACHING

GARNET TODD
Harrison School, East Chicago, Indiana

Add the sense of curiosity to the senses of taste, touch, smell, hearing, and sight and you have the makings of good elementary science . . . add to this an abundance of enthusiasm and you have the makings of good elementary science teaching.

Almost any everyday experience holds surprises in scientific truths for children as well as adults. Such simple things as getting up in the morning, turning on the radio, running water in the tub, putting on clothing, drinking chocolate sodas, watching cats, dogs, birds, and other animals in their daily lives, smelling flowers or burning leaves, watching the flight of birds, experiencing day and night, all contain many many ideas for starting children in elementary science.

The teacher of elementary science need not be a specialized teacher. All that any teacher needs in order to teach children scientific truths is to have a sense of curiosity herself, and to show lots of enthusiasm. The smallest article brought into the room and proudly shown by a child becomes to that child an all-consuming interest. The teacher, in turn, uses the child's interest to bring about interest in related subjects. One subject in nature study leads naturally into a related subject in the same field. For instance, a lovely leaf leads to a discussion of trees, insects, and birds. In the same manner, a seed leads to the discussion of the life cycle of almost any living thing.

In teaching the parts of elementary science which are not related to living subjects, every-day experiences play the greatest role. For example . . . a chocolate soda may be tasted . . . it feels cold; it is beautiful to see; and sipping through the straw excites the curiosity to experimentation. Almost every child has sucked the brown liquid up part-way in the straw and then let it fall back into the glass. When this is experimented with in actuality in a class room, the "why" soon becomes a part of that experiment. The vacuum created when the air is taken out of the straw soon fills with the liquid from the bottom of the glass because air is pressed down on the liquid . . . so one phase of air pressure may be taught.

The more we can appeal to children to bring into the class

room the things of interest to them in their every day living, the more the child will be able to see an orderly pattern in life.

Almost every teacher uses the seasons every day in some form of teaching. The easiest way of teaching elementary science is to use those things which may be found through each season of the school year and brought into the class room. With the added knowledge which may be had by both teacher and pupil from books on subject material, both the teacher and pupil discover what has already been learned about the object brought into the room. The element of surprise should not be taken away from the child in his discovery of something new and different.

In the fall of the year, most teachers will correlate such subjects as flowers, trees, seeds, insects and birds. In the winter time when living objects are hard to find, it is easy to study such things as weather, stars, planets and to go into the study of the earth's formation, the study of air, rocks, and minerals. In the spring of the year, the subjects that were taught in the fall may be presented in reverse. Of course, the study of animals is interesting to children at any season of the year. The seasonal order doesn't mean that subjects in which children are especially interested need be neglected. They can be carried on by the individual child at all times.

The elementary science room should be a place where children feel free to come and use all the "six senses" mentioned in the first paragraph. The windows of a science room may be a good place to portray the various seasons. Starting in the fall, colored leaves may be placed on the windows, then pumpkins added . . . frost to the pumpkins . . . stalks of corn . . . perhaps the phases of the moon to further show the seasonal change.

The ability to arouse children's curiosity in the things around them lies with the individual teacher's enthusiasm. Current magazines and books on scientific subjects may be of vast interest to those children with scientific minds. The high school teacher will be duly appreciative if children are able to think and act in an orderly fashion.

So much of the school day is spent by children either reading books or writing lessons, that the opportunity to use the senses in a science class is a bright spot in their day.

In helping teachers to know of some of the ways that certain activities have aided in the teaching of elementary science, succeeding articles will go into detail in describing those activities.

A METHOD FOR TEACHING FORMULA WRITING AND STRUCTURAL DIAGRAMING IN HIGH SCHOOL CHEMISTRY

KENNETH E. ANDERSON
University High School, University of Minnesota

One of the weaknesses in the teaching of high school Chemistry is that, at the end of a year's work, students are unable to write correctly the formulas of many chemical compounds, unless they have learned them by rote. Memorization of formulas does not lead to a comprehensive understanding of valence, and neither does the student appreciate the structure of compounds. Equation writing and problem solving based on equations, are made so much easier if the student has the basic tools of formula writing firmly fixed in his chemical habits.

There are many methods of teaching formula writing. The writer has found over a period of years, that if students are taught formula writing and structural diagraming by the method illustrated in this paper, they gain an excellent foundation for the work to come later in chemistry. The method has value in that it gives direction to the teaching of formula writing.

In this particular article, let us confine ourselves to formula writing and structural diagraming for binary acids. Binary acids contain only two elements, hydrogen and the acidic element. There is no oxygen in binary acids. An example of a binary acid is hydrochloric acid or HCl. Chlorine is considered the acidic element in this particular case. The following are the steps in writing formulas for binary acids:

1. Write the name of the acid.
2. Write the symbol for hydrogen (*H*) before the symbol of the acidic element.
3. Above each place the proper valence selecting the simplest valence for the acidic element.
4. Criss cross valences.
5. Rewrite, dropping subscript numbers 1 wherever they appear.

The following is an example for hydrosulfuric acid:

1. hydrosulfuric acid
2. H S
3. H^1 S^2 (valences written as if they were exponents)
4. H_2 S_1 (valences criss crossed)

5. H_2S (Drop 1's)

The following steps are used in diagraming the structures of binary acids:

1. Determine the correct empirical formula by the above method.
2. Set down as many atoms of the acidic element as indicated by the formula.
3. Using short straight lines, indicate the valence of the acidic element, one line for each valence. (This is always the valence of the acidic element as in step three for formula writing.)
4. Attach the hydrogen directly to the acidic element, one valence line to each hydrogen atom.

The following is an example for hydrosulfuric acid:

1. H_2S
2. S
3. S —
   — H
4. S — H

THE MALADY AND HOW TO CURE IT

1. Shortage of qualified teachers is universal.
2. More and more unqualified emergency teachers are being hired in a desperate attempt to keep school open at all.
3. Many schools and classes are closed because teachers cannot be obtained.
4. Many classes are overcrowded or too large for effective instruction.

It would be less tragic if this problem were only temporary. But it is not. The needed supply of new teachers is being cut off because capable young people are not preparing to teach.

In the long run the social consequences of an inadequate, poorly-financed, under-staffed educational program is something that this nation as a world leader cannot afford to tolerate.

Action now is imperative. Pious statements, half-hearted efforts, and promises lightly entered into must be replaced by vigorous action.

What America will pay tomorrow for neglecting its human resources today will be tenfold the cost of loosening the rubber bands on the community, state, and national wallet—NOW! Such action will:

1. Give today's teachers a living salary.
2. Show our young people who are planning their life work that we think enough of the education of our children to make teaching a worth-while profession.
3. Insure better teaching for 30,000,000 American children and young people.
4. Provide the knowledge and skills upon which the United States must depend for its security both domestic and international.

TO EXPLAIN THE GYROSCOPE

GEORGE P. UNSELD
West High School, Salt Lake City, Utah

Of late years there has been an enormous increase in the use of gyroscopic devices. The gyro-compass is extensively used on the larger ships. Aviation depends on the turn-and-bank indicator and the artificial horizon for blind flying, and also uses the automatic pilot and the bomb sight. Gyroscopic instruments show the firing officer at what instant the guns on tossing warships should fire, and they stabilize the aim in rolling tanks. The principles of this instrument explain why a coin rolls along

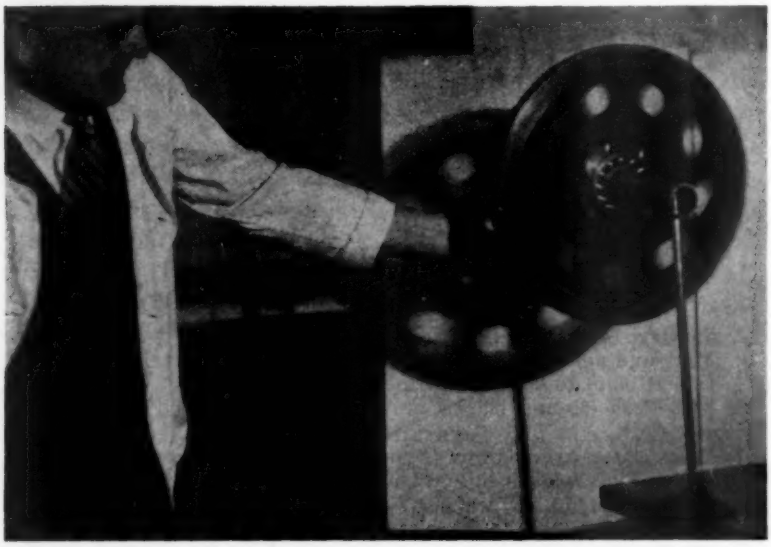


FIG. 1. A 40-lb. wheel precessing as a gyroscope.

a spiral, why the equinoxes precess around the elliptic, and why the rotating propeller has held up the noses of airplanes in spite of the utmost efforts of skilful pilots.

The not uncommon impression that gyroscopic phenomena cannot be explained without resorting to advanced mathematics is false. This we shall now attempt to show. The fundamental principle here is expressed by the well-known formula $F = Ma = M\ dv/dt$. This says that the numerical value of any force can be calculated from the numerical values of the mass involved and the rate at which its velocity is changing, provided the

correct units are used; changing momentums are always accompanied by forces. As the mass can be considered as constant in most cases, the change in momentum results from either a change in the magnitude of the velocity, or from a change in its direction.

Let us consider a stream of water from a hose that strikes a flat surface, so that there results a change in the direction of the stream with a negligible change in the speed of the water particles. As we change the angle at which the stream strikes the plate we note that the force on the plate changes with the rate

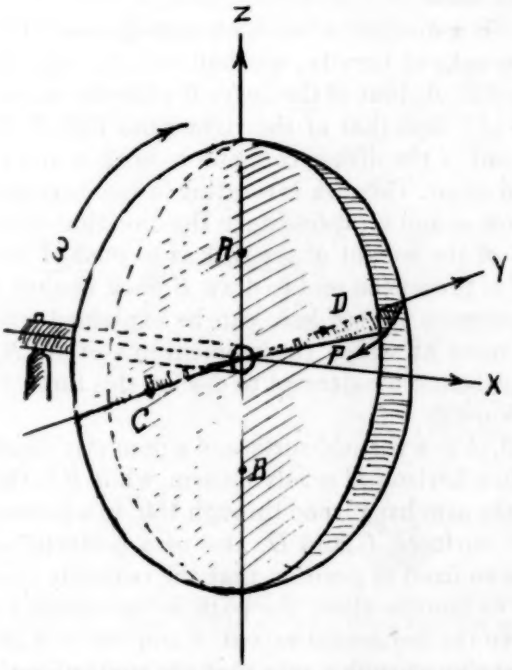


FIG. 2. Diagram showing the masses and motions involved in explaining the cause of precession.

at which the momentums of the particles change. When there is no change in the momentums of the particles there is no force, and hence we can think of the force as caused by the rate at which momentum is changing. If we care to analyze this further we see that the momentums of the particles, upon striking, produce compressions and the elasticities of the substances then produce forces, which, reacting on the particles, produce changes in their momentum.

The two important properties of the gyroscope are the tendency for the rotating mass to remain in the same plane relative to the fixed stars, and the phenomenon called precession. As the first of these is not difficult to understand, we shall restrict our remarks to matters that have to do with the second. When discussing this, the most striking experiment we have been able to devise is to cause a heavy mass to rotate and to precess at the end of a lever arm, apparently floating in the air. We have found that a wheel weighing 40 lb. (Fig. 1) can easily be caused to do this when it has been set into motion by only one vigorous turn by the hand.

Figure 2 is a diagram of such an arrangement. In the following, for the sake of brevity, we shall call the mass of the upper half of the disk A, that of the lower B while the mass of the left-hand half is C and that of the right-hand half D. Notice that one quadrant of the disk is common to both A and D, one to D and B, and so on. The disk is rotating in the direction indicated by the arrow ω, and is precessing in the direction of the arrow P. The effect of the weight of the disk is to push A forward from the center of precession and to draw B back toward that point. The phenomenon we see here can be explained when we consider the rates at which the momentums of A, B, C and D change, but before we attempt to discuss this further let us look at the following.

In Fig. 3, A is a vertical surface of a perfectly elastic material attached to a horizontal revolving arm, while B is the same surface after the arm has turned through 180° in a horizontal plane. Two other surfaces, C and D, also of a perfectly elastic substance, are so fixed in position that the perfectly elastic ball M continues to bounce along the path as indicated. Let the ball strike above the horizontal axis at A and below it at B, and let the arm revolve at such a rate that the vertical surface arrives at A and B at the same instants that the ball does. If there is no friction whatever, the apparatus being in a perfect vacuum, it is evident that the ball will continue to bounce from surface to surface continually, and the mass at the end of the axle will be held up against the pull of gravity by the force of the blows. A slight falling of this mass between blows will give it additional momentum, which in turn will add exactly the right amount to the force of the blows to restore the axle to the horizontal position. (A perfectly elastic ball would rebound to the same height from which it fell.)

Notice that in this motion, the ball does not change its speed at all, but with each blow there is a change in momentum because there is a change in velocity. Also note that the change in velocity is due to a change in the direction of the path of the ball.

We are now ready to return to the gyroscope. First we think of A (Fig. 2) as the ball and D as the vertical surface. At each instant all the particles of A have a certain component of velocity toward the right, but when the disk has made a quarter turn each of these particles now has an equal component downward. The total momentum of each particle of the entire disk can be broken into a horizontal and a vertical component. Thinking of A and B as masses, we see that the effects of the

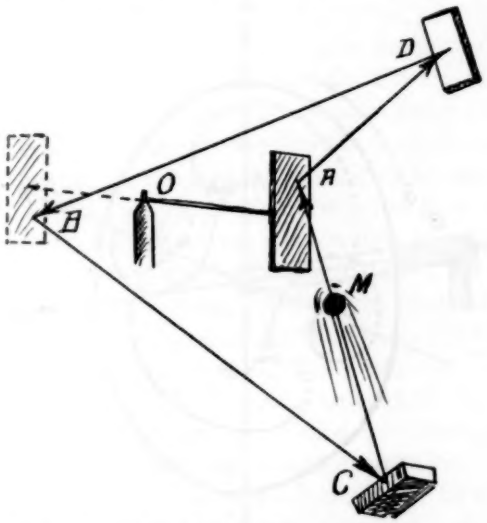


FIG. 3. An imaginary experiment that illustrates the production of forces due to impact; the speed of the striking mass remains unchanged.

vertical components of the particles in A neutralize each other while the same is true for the horizontal components in B. Hence the result is the same as though the horizontal component of the momentum of A were transferred into the vertical component of the momentum of B.

We now turn our attention to the effect of the force of gravity. It is at right angles to the horizontal components of the momentums of the particles in A. Therefore it cannot increase the speeds of the particles along horizontal lines, but it does affect the directions of their velocities. When A reaches the position previously occupied by B its particles have acquired a com-

ponent of momentum toward us and perpendicular to the plane of the disk. As B bears exactly the same relation to C as A does to D, and the acquired component of momentum of B is in exactly the opposite direction to that acquired by A, we see that a couple is produced that causes precession. The effect is the same as though A were a ball that struck D from the rear, and B one that struck C in front.

Precession has now taken place and we consider the effect of D on B and of C on A. We follow exactly the same line of reasoning as before. Again we see that the effective directions of the momentums of the particles are changing and necessarily a force

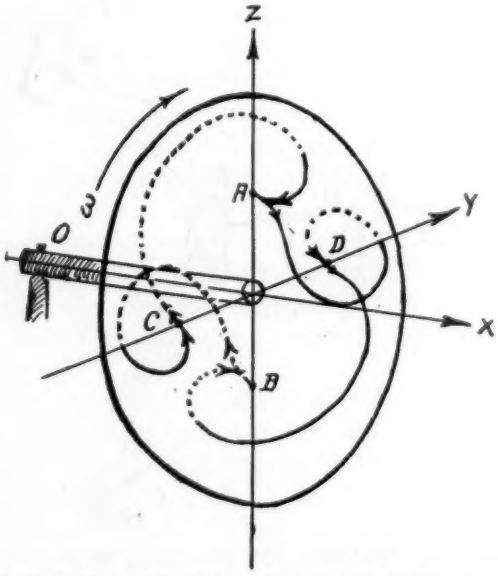


FIG. 4. Diagram to illustrate momentum changes occurring within the rotor of a gyroscope.

accompanies this change. Otherwise the relation $F = M\ dv/dt$ would not hold. The effect is as though D struck B from the rear and C struck A from the front. The forces produced by these blows must exactly counterbalance the force of gravity. This results from matters of symmetry and the fact that the relation $F = m\ dv/dt$ always holds.

Also the faster the rate of rotation, the slower that of precession. As with a falling body, where $s = \frac{1}{2}gt^2$, so here the total deflection varies as the square of the time. If the rate of rota-

tion is halved, it takes twice as long for any particle to pass from one quadrant to the corresponding position in the next quadrant, and at the same time the angular change that measures the rate of precession is four times as great. Four times the change in twice the time results in twice the rate of precession.

A very handy rule for use in connection with gyroscopic forces is the "straightedge rule," namely: ***the effect of any force applied to a gyroscope may be thought of as due to the pressure of a straightedge against the axle; the direction of precession is that in which the axle rolls along the straightedge.*** This rule gives one the proper direction in which a tipping coin rolls, in which the equinoxes precess around the ecliptic, in which the rotating propeller forces the nose of an airplane, as well as the direction of precession of a simple rotating disk.

A word may well be said here about the gyro-compass. Let a disk rotate with its axle in the plane of the meridian and pointing horizontally. As the axle continues to point to the same spot on the celestial sphere, we see that the north end veers to the east and upward. If the disk is rotating in the same direction as the earth, and if a weight is attached below so as to pull the axle back into a horizontal plane, we see that precession will cause the axle to return towards the north point. In the gyro-compasses now in general use, this weight consists of a mass of mercury contained in connecting vessels. As the north end of the axle tends to rise, the mercury flows into the south chambers and the effect is exactly opposite to that of a rigidly attached solid mass. Therefore the rotor of a gyro-compass using mercury rotates contrary to the direction in which the earth does. If it is difficult to see the above, think of the mercury as in a horizontal tube which it does not completely fill, and having the center of gravity of the liquid at the center of the rotating disk. The slightest tilt of the north end upward causes the mercury to run into the south end, and this tends to raise the north end even higher. This is the general principle of the gyro-compasses in use at present, though there is much more to be taken into consideration. Continuous rotation is secured by replacing the disk by the rotor of an induction motor, and friction is minimized by an electric follow-up system that turns a part of the supporting framework so as to keep it aligned with the rotor. The oscillations of the axle are damped by an ingenious device, and adjustments can be made to compensate for errors due to the speed and course of the ship and its position in latitude.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED SIXTY-THIRD MEETING

St. George's School
Middletown, Rhode Island
Saturday, 26 October 1946

MORNING PROGRAM

10:00 Address of Welcome
Dr. Willet L. Eccles, Headmaster, St. George's School
10:15 Address: Recent Advancements in Metallurgical Materials
Mr. Carl Rex, Chief Metallurgist, U. S. Naval Torpedo Station
11:00 Address: A Physicist at Bikini
Dr. John Formwalt, Physicist Naval Observer
12:00 Luncheon

AFTERNOON PROGRAM

1:30 Report of Apparatus Committee
2:15 Address: The Evolution of the Torpedo
Capt. William S. Whiteside, U. S. N., Officer-in-Charge, Design, U. S. Naval Torpedo Station
3:00 Address: The Manufacture of the Standard Cell and Pyrheliometer
Mr. William Gray, Chief Engineer, Eppley Laboratories
4:00 Business Meeting

Officers of the Association for 1946–47

President: John T. Gibbons, Brighton High, Brighton, Mass.
Vice-President: Anna E. Holman, Winsor School, Boston Mass.
Secretary: Albert Thorndike, Milton Academy, Milton, Mass.
Treasurer: Albert R. Clish, Belmont High, Belmont, Mass.

REPORT OF BUSINESS MEETING

The following were elected to Active Membership:

Harwood Ellis, Rivers Country Day School, Chestnut Hill, Mass.
Harold M. Hawkes, Braintree High School, Braintree, Mass.
Nickerson Rogers, Loomis School, Windsor, Conn.
Richard M. Whitney, Roxbury Latin School, West Roxbury, Mass.

APPARATUS COMMITTEE REPORT

Charles S. Lewis (Brighton High School, Brighton, Mass.), demonstrated a *Sound Disk* made of eighth-inch sheet steel and mounted on a quarter horsepower motor. This disk was much more sturdy and lacking in vibration than the usual ones supplied by apparatus companies; it had four circles of holes (8, 6, 5, and 4 openings). The openings were elongated slots about 5 mm. wide and 20° of arc long; each ring was approximately 30 mm. from the adjacent ones, the whole disk being about 250 mm. in diameter. With this disk, an amplifier, and an oscilloscope, demonstrations were shown of the frequency ratios of the octave and major triad using an air-jet and microphone, a photoelectric cell pickup from a flashlight, and

a magnetic pickup showing the principle of a Hammond Organ. For the latter a Gilley coil slipped over a bar magnet was held near the circles of holes.

Carl Johnson (North High School, Worcester, Mass.) showed two pieces of apparatus for experiments on airfoil sections to demonstrate the effect of varying angle of attack on lift and drag and experiments on different shapes for streamlining.

Hollis D. Hatch (English High School, Boston, Mass.) demonstrated a simple apparatus for showing the effect of color on *absorption and radiation of heat.* Wax was used to affix pencil stubs to the outside of a tin can which then was placed over a light bulb. The stub on the side of the can which had been painted black on the inside fell off first. A can painted black on one half of the outside was used to show that radiation from that surface was more rapid by having the stub on the shiny side fall off first.

W. Roscoe Fletcher, Chairman of the Committee (North High School, Worcester, Mass.) showed several one-octave xylophones constructed of wood and one made of brass tubing. These were made to demonstrate how the frequency produced depended upon the length of the bar and also the thickness in the direction of motion of the hammer according to the formula

$$f \propto \frac{Ad\sqrt{e}}{L^2\sqrt{D}}$$

where A is the spacing of supports, d the thickness, e Young's Modulus, L the length, and D the density of material.

RECENT ADVANCEMENTS IN METALLURGICAL MATERIALS

CARL REX, *Chief Metallurgist, U. S. Naval Torpedo Station*

Commercial industry is coincident with the progress of making lighter, better and cheaper steel. That the world has wasted much of this progress in an effort to destroy itself through senseless wars is simply evidence that science has traveled faster and further than man's sense of moral responsibility. Let us leave the problem of moral standards for others better equipped and proceed with the advances in material standards of living.

It has been stated that steel has permitted the extension of mechanical power and the important broadening of man's effective labor results. Iron fulfilled a great mission but it was too weak and bulky to retain its position in competition with steel. Magnesium has one quarter the weight of steel and aluminum approximately one third. We as yet do not have magnesium alloys which equal the strength of steel but several aluminum alloys have already passed the figure used by designers for common steel. The trend in engineering is to use the lightest material which will satisfactorily bear the stresses to be imposed. Even steel is striving for higher and higher strength alloys which will permit lighter weight construction. Magnesium

will inevitably be considered for use in the construction of anything which must be moved about.

Let us consider a simple wheelbarrow made of magnesium which is already on the market. The ordinary old style brick-layer's wheelbarrow weighed 85 pounds. The new weighs 30 pounds, which means the workman moves 55 pounds less deadweight each time he moves a load. A load of brick here weighs 300 pounds but the man can now move 355 pounds, a gain of 18.3%, or nearly one-fifth more than he could move before. This is a direct saving in human energy, which may be expressed in money, or any other base you may choose. Magnesium now is used for airplane wheels on all standard craft, but when first proposed it was difficult to get even a trial run made. It is now being investigated for use on automobiles. And it may interest you to know that, if only 75% of the models use magnesium wheels it will call for a production of magnesium which will test the nation's capacity to produce on this one product alone.

Business does not move from the laboratory out; it moves from the customer in. Contrary to much scientific thought, it is the customer's demand which creates a piece of equipment. To make a machine which people need is to make a fair living, but to produce an article which people want is to make a fortune. You will remember that it took a great many years for the automobile makers to realize that a motor car was not a horseless carriage, but actually an entirely new form of transportation. Some old carriage trade names still hang on the car today. It was the public demand forcing the introduction of the closed car which made cars available for winter use. It used to be taken for granted that a car had to be set upon blocks and put away for the winter. Some New Englanders still do it. When one observes the differences between the modern chemical torpedo and the old Whitehead steam type of 30 years ago he is conscious of a tremendous development. The mechanical engineer has combined his knowledge of improved design with the latest developments in the metallurgical field.

Some people, however, do not seem to realize that improvements in materials make possible the really great steps in mechanical engineering. Of what advantage is it to design a turbine for operation at 1800° F. if no material exists which will withstand the stresses to be imposed at such a high temperature? It is very easy to see that design and material are dependent one upon the other. Let me review a few of the advances in materials and processes for you. Stainless steel, chromium plate, high strength welding, induction melting and heating, metal spraying, synthetic rubber are all so well known that it is hard to realize that they were not even available in World War I. Just within the past 16 years we have introduced and put to good use silver brazing, beryllium copper, precision castings, columbium and titanium, selenium, sintered carbides, powdered metals, molybdenum high speed steel, nitralloy, heat treated aluminum castings, and the special high temperature alloys which are already far along the road toward supplanting the internal combustion engine from its throne in the transportation field.

The jet engine will develop into a very efficient gas turbine engine which need not be used on planes and in which the engine itself is stationary but the exhaust blast of hot gases is directed against the turbine wall which absorbs the energy and gives high speed rotary motion for conversion into useful energy for industrial purposes. Already research workers in General Motors have stated that by 1950 there will be cars on the road which will employ this lightest and most efficient of all rotary engines. Your two hands will practically encircle the whole motor, the turbine of which will measure about 5 inches in diameter and will revolve at about 25,000 r.p.m. What will the fuel be? That I cannot say, but one thing is almost certain, and that is it will not be gasoline. Think what a revolution this will be to our petroleum industry with its millions of dollars tied up in corner stations and gasoline equipment.

No discussion of modern materials would be complete without reference to Uranium, Neptunium, and Plutonium and their connection with atomic power. The significance of the man-created elements just mentioned is too great for a mere materials engineer to attempt to sum up in the presence of a group of physicists. A few weeks ago I visited the Clinton Laboratories of the Monsanto Chemical Co. at Oak Ridge, Tenn. and was amazed to see acres of plants devoted to the mass spectrographic and gaseous diffusion processes of atomic separation for the production of impure plutonium; this was to be further refined at Los Alamos and incorporated in military weapons. Already thoughts of war uses are placed secondary to the desires for peace time applications. Plans are past the drafting-board stage for the construction there of the first steam driven electric power plant which will use the Daniels pile to create atomic heat for industrial purposes. It is no secret that it is practical now to use such motive power in battleships where the weight of the necessary 15 feet of insulation around the carbon pile generator is known to be much less than the weight of the necessary fuel oil and combustion equipment of the present system. The carbon pile at the Clinton Laboratory was at the time of my visit being used to produce isotopes for medicinal use, and four such products were ready for delivery with many more in sight. There was everywhere the discussion of research, more and more research. What materials will stand up under the constant bombardment of neutrons, and gamma rays? What materials should be used to withstand the terrific heat of atomic decomposition? Three things are of paramount importance. First, the terrific amount of possible power must be brought under control so that it may be used when and where and at whatever rate desired by an ordinary workman. Gasoline was once a useless by-product of the manufacture of kerosene, but the internal combustion engine solved that problem. Even now it is estimated that only 3 to 5 years are necessary to perfect an engine which will place atomic power under the constant control of the operator. Second, the cost of atomic fuel must be reduced from the present cost of about $100,000 per pound to some more economic figure. It is estimated that at $6000 per pound it will be cheaper than coal. However in view of the fact

will inevitably be considered for use in the construction of anything which must be moved about.

Let us consider a simple wheelbarrow made of magnesium which is already on the market. The ordinary old style brick-layer's wheelbarrow weighed 85 pounds. The new weighs 30 pounds, which means the workman moves 55 pounds less deadweight each time he moves a load. A load of brick here weighs 300 pounds but the man can now move 355 pounds, a gain of 18.3%, or nearly one-fifth more than he could move before. This is a direct saving in human energy, which may be expressed in money, or any other base you may choose. Magnesium now is used for airplane wheels on all standard craft, but when first proposed it was difficult to get even a trial run made. It is now being investigated for use on automobiles. And it may interest you to know that, if only 75% of the models use magnesium wheels it will call for a production of magnesium which will test the nation's capacity to produce on this one product alone.

Business does not move from the laboratory out; it moves from the customer in. Contrary to much scientific thought, it is the customer's demand which creates a piece of equipment. To make a machine which people need is to make a fair living, but to produce an article which people want is to make a fortune. You will remember that it took a great many years for the automobile makers to realize that a motor car was not a horseless carriage, but actually an entirely new form of transportation. Some old carriage trade names still hang on the car today. It was the public demand forcing the introduction of the closed car which made cars available for winter use. It used to be taken for granted that a car had to be set upon blocks and put away for the winter. Some New Englanders still do it. When one observes the differences between the modern chemical torpedo and the old Whitehead steam type of 30 years ago he is conscious of a tremendous development. The mechanical engineer has combined his knowledge of improved design with the latest developments in the metallurgical field.

Some people, however, do not seem to realize that improvements in materials make possible the really great steps in mechanical engineering. Of what advantage is it to design a turbine for operation at 1800° F. if no material exists which will withstand the stresses to be imposed at such a high temperature? It is very easy to see that design and material are dependent one upon the other. Let me review a few of the advances in materials and processes for you. Stainless steel, chromium plate, high strength welding, induction melting and heating, metal spraying, synthetic rubber are all so well known that it is hard to realize that they were not even available in World War I. Just within the past 16 years we have introduced and put to good use silver brazing, beryllium copper, precision castings, columbium and titanium, selenium, sintered carbides, powdered metals, molybdenum high speed steel, nitralloy, heat treated aluminum castings, and the special high temperature alloys which are already far along the road toward supplanting the internal combustion engine from its throne in the transportation field.

The jet engine will develop into a very efficient gas turbine engine which need not be used on planes and in which the engine itself is stationary but the exhaust blast of hot gases is directed against the turbine wall which absorbs the energy and gives high speed rotary motion for conversion into useful energy for industrial purposes. Already research workers in General Motors have stated that by 1950 there will be cars on the road which will employ this lightest and most efficient of all rotary engines. Your two hands will practically encircle the whole motor, the turbine of which will measure about 5 inches in diameter and will revolve at about 25,000 r.p.m. What will the fuel be? That I cannot say, but one thing is almost certain, and that is it will not be gasoline. Think what a revolution this will be to our petroleum industry with its millions of dollars tied up in corner stations and gasoline equipment.

No discussion of modern materials would be complete without reference to Uranium, Neptunium, and Plutonium and their connection with atomic power. The significance of the man-created elements just mentioned is too great for a mere materials engineer to attempt to sum up in the presence of a group of physicists. A few weeks ago I visited the Clinton Laboratories of the Monsanto Chemical Co. at Oak Ridge, Tenn. and was amazed to see acres of plants devoted to the mass spectrographic and gaseous diffusion processes of atomic separation for the production of impure plutonium; this was to be further refined at Los Alamos and incorporated in military weapons. Already thoughts of war uses are placed secondary to the desires for peace time applications. Plans are past the drafting-board stage for the construction there of the first steam driven electric power plant which will use the Daniels pile to create atomic heat for industrial purposes. It is no secret that it is practical now to use such motive power in battleships where the weight of the necessary 15 feet of insulation around the carbon pile generator is known to be much less than the weight of the necessary fuel oil and combustion equipment of the present system. The carbon pile at the Clinton Laboratory was at the time of my visit being used to produce isotopes for medicinal use, and four such products were ready for delivery with many more in sight. There was everywhere the discussion of research, more and more research. What materials will stand up under the constant bombardment of neutrons, and gamma rays? What materials should be used to withstand the terrific heat of atomic decomposition? Three things are of paramount importance. First, the terrific amount of possible power must be brought under control so that it may be used when and where and at whatever rate desired by an ordinary workman. Gasoline was once a useless by-product of the manufacture of kerosene, but the internal combustion engine solved that problem. Even now it is estimated that only 3 to 5 years are necessary to perfect an engine which will place atomic power under the constant control of the operator. Second, the cost of atomic fuel must be reduced from the present cost of about $100,000 per pound to some more economic figure. It is estimated that at $6000 per pound it will be cheaper than coal. However in view of the fact

that 90% of the cost of electric energy lies in the cost of distribution it is highly possible that the ultimate consumer will never see any of the saving which is created by the adoption of atomic fuel in generating stations. Third, atomic fuel must be made safe for handling and transportation without loss of life from deadly rays that are emitted as the atoms change their arrangements. This third point may appear to be of minor importance but it is certain to be the main hurdle in years to come for the introduction of atomic fuel in pellet form to home heating and general use.

Now let us leave the subject of atomic energy to those who are better qualified than myself to speak about it and return to a field of metallurgy in which I feel more at home. There is little doubt but what aluminum and magnesium will be the chief competitors of steel for the quantity market in the future, yet neither of these two metals is sufficiently strong when in the pure state to offer anything worth talking about on a strength basis. The problem of high strength combined with low weight has caused so much research in the field of alloys for the improvement of light metals that the gap between the strength of steel and the strength of aluminum materials has not only been closed but in many cases has been surpassed to a very appreciable degree. Even magnesium has been strengthened until certain of its alloys are equal to the weaker forms of common steel.

A PHYSICIST AT BIKINI

JOHN FORMWALT, *Physicist Naval Observer*

Unfortunately, many subjects of considerable interest, such as details of experimental equipment and techniques, cannot be discussed because of the network of security regulations covering Operation Crossroads.

Last March the Navy Bureau of Ships requested that my services be lent to their Instrumentation Group for Operation Crossroads; and after two days of mad rushing to get ready, I was on my way to Washington. There activities were almost as feverish. For five days we took "shots," discussed the various scientific problems to be undertaken by our group, and visited government laboratories to beg, borrow or otherwise acquire any suitable equipment that might be available. Throughout the operation we received splendid cooperation from other activities. The David Taylor Model Basin was extremely helpful in lending equipment, and almost overnight their electronics section built to my specifications an instrument that was not otherwise available.

By the end of that week in Washington I had been given a pretty good overall picture of the operation, and had been assigned certain programs for which I was to be jointly responsible with another physicist, Mr. W. H. Christie, of Pasadena, Calif. About this time the postponement of the operation was announced, and I went to Pasadena, where Mr. Christie is

employed by the Naval Ordnance Testing Station; he also was on loan to the Bureau of Ships. Other members of his organization gave us splendid cooperation, and in five weeks we were able to design and construct two diffraction grating spectrographs. We were able to borrow from Mount Wilson Observatory and other places beautiful optical equipment—diffraction gratings, lenses, etc.—and the rest we built with our own hands, largely from plywood, so designed that the large and bulky equipment could be broken down into easily portable sections. We had intended to build a third spectrograph, but abandoned it in the blueprint stage because of lack of time.

When the time came to leave for San Francisco, where were we to board ship, the two grating spectrographs were completed and we had assembled an imposing collection of high-speed cameras and auxiliary equipment. We borrowed a large Navy truck from the nearby Naval Supply Depot at Terminal Island, and set out. At one o'clock the next morning we reported to our ship, handed over the truck load of instruments to the officer of the deck, and went in search of the room that was to be home for the next few months.

Our ship was the U.S.S. *Wharton* which had served as a transport during the war. Before being taken over by the Navy, she was known as the *Southern Cross*, and made the run to Australia; at one time she had served as Admiral Byrd's flagship for an Antarctic expedition. She was a large and comfortable ship, fairly old, but reasonably fast. Her lines, when seen from a distance, were those of a child's sketch of a steamer—all straight lines, with a large flat superstructure running half the length of the ship. This made her easy to recognize even from a great distance, which proved to be quite a convenience later.

The voyage from San Francisco to Hawaii was very pleasant and uneventful. Our time was spent in unpacking and setting up equipment in our laboratory, discussing problems with other interested groups, and perfecting plans for our work when we reached Bikini. We spent ten days in Pearl Harbor, much of the time in the Naval Supply Depot checking our equipment that had been sent ahead or trying to obtain additional equipment. The Naval Operating Base did everything they could to make on stay pleasant; a large fleet of jeeps was made available for recreation purposes after working hours, and we saw a lot of the island that we could never have seen without them.

When we reached Bikini we found that all natives had already been removed to another nearby atoll, and the Seabees were in full possession except for a few early scientists and engineers. We immediately visited the site that had been selected on one of the islands for our battery of high speed cameras and spectrographs, and were disappointed to find that it was not suitable for the purpose. The island was low; and the line of sight from it to the target area several miles away passed close above a long line of coral reef. Looking out to sea the spray thrown up by waves striking the

reef seemed light and quite transparent; but looking through two or three miles of it was something very different. The amount of light absorbed in passing through the miles of water vapor was tremendous. We began a search for a more suitable location, and were able to find a tower which the Seabees had built on Enyu Island, some miles to the southeast of the orignal location, which seemed satisfactory. We had to wait a few days for official permission to make the change, but finally got to work remodeling the tower to accommodate our equipment. The entire top of the tower had to be a photographic dark-room; so we erected ply-wood walls, sealing the cracks with masking tape. Other towers nearby had lead walls and heavy lead shutters to protect film from fogging due to radioactivity; we took considerable joking about our plywood and masking tape, but results proved our contention that radioactivity would not be harmful at that location.

It took about three weeks to modify the tower, install the equipment, and make preliminary tests. Then for the first time we were able to test the two home made spectrographs by making trial exposures of the sun. Results were more than satisfactory, and put an end to a long period of anxiety. We felt much happier to know that we had built instruments that would work.

Enyu Island was about a mile and a half long, perhaps a quarter mile wide at its widest point, and roughly crescent shaped. It is not the largest island in the atoll, but is one of the larger ones and had some permanent inhabitants. Bikini Island is the largest, and by far the largest group of natives had lived there. The islands are formed of coral, with beautiful white coral sand on the beaches. Coconut palms are the most notable features of the landscape; not the tall trees bearing large coconuts such as are shipped to this country, but a smaller variety used only for copra. Wild nutmeg is also fairly plentiful, and bears fragrant white flowers.

Animal life was not plentiful; on Enyu there were a few chickens, pigs, and cats that could not be caught when the natives left; all were completely wild and rarely seen. There were apparently no land birds, but the small albatros and a variety of seagulls were plentiful. Hermit crabs were everywhere; every available shell had a crab in it, and the housing shortage was so acute that many of them were carrying around shells that they could not possibly get into. In the water there was an endless variety of strange and beautiful tropical fish, and many kinds of coral formations. The water was usually so clear that the bottom could be seen distinctly through thirty feet or more of water; and the temperature was perfect for swimming.

The climate was warm but not oppressive. Daily temperatures were usually about 80° to 85°, with relative humidity of about 80%. At night the temperature would drop about 10°.

Frequently we stayed on the island rather than return to the ship at night, since the trip required about an hour each way by small boat, and we needed the working time. Usually we slept in the open on canvas cots;

when necessary we made a shelter of a tarpaulin. K-rations provided our meals, and water was carried in from the ships. The natives had used cisterns for their water supply, with large sheets of metal roofing to catch rainwater; their only other sources of fresh water were coconut milk and raw fish. The Seabees had set up an evaporator unit, but it broke down too late for them to repair it before they left the island, soon after we arrived.

On the morning of July 1 we started up the generator supplying power to our equipment, loaded film in the cameras and spectrographs, and left the island by small boat at four A.M. At five we boarded the U.S.S. *Kenneth Whiting*, which immediately put out to sea. Our own ship, together with most other non-target ships, had left the lagoon the day before. From a safe distance we watched the bomb burst, and it was truly a remarkable sight as the billowing incandescent gases shot upward and slowly dispersed. Cautiously we steamed back into the lagoon, and early that afternoon I returned to Enyu, accompanied by a radiological monitor, to recover exposed film and other records. Various safety precautions were observed following the blast to insure against dangerous over-exposure to radioactivity; most of these are covered by security regulations, but some publicity has been given to the monitors who carried portable Geiger counters and other instruments for detecting and measuring harmful radiation.

Since few changes were to be made in our experimental equipment for the second test, I had time following the blast to assist in other research programs undertaken by our group, involving pressure, temperature, and magnetic measurements. In the course of this work I boarded many of the target ships to obtain data from the first test and set up instruments for the second, and again after the second test to obtain more data.

The program for the second test was much the same as for the first; we spent the night and early morning loading cameras and making final adjustments, and left Enyu before daylight to board the ship and leave the lagoon. We were much closer to the target area for the underwater shot, and it was even more spectacular than the first. I stayed on deck until the sound and pressure blast reached us then hurried into a darkened compartment to watch a television screen as the waves washed up on the beach. This time we entered the lagoon even more cautiously than before; but again I was able to visit Enyu and remove the records in the early afternoon.

For almost a month after the second test I stayed at Bikini, recovering instruments and data from target ships and from the islands. Most of our group left to come back to this country when a large part of the work was done, but I stayed on to help finish the work in the target area. Finally on August twenty-first I left Bikini by Navy flying boat. We expected to leave Kwajalein that night; but the report when we reached the Air Transport Command terminal was "Sorry—no plane." The next night we did a little better; we took off and headed for Johnson Island, but about a hundred

miles out one engine died and the pilot received a report of storms ahead, so we turned back. A quick check-up showed that the engine would have to be replaced; and it would take three days to get a new one. Fortunately an unscheduled plane turned up the next day, and this time we completed an uneventful flight to Fairfield, California, by way of Johnson Island and Hickam Field.

Since returning to this country I have frequently heard people express the opinion that the atomic bombs were near-duds, not much more effective than bombs of the ordinary variety. This was probably due in part to poor reporting of the forecasts of recognized authorities and to the publicity given to wild guesses of people who let their imaginations carry them away. The public had been led to expect too much. The results were less world-shaking than some prophets of calamity had foreseen; none of our west-coast cities were destroyed by tidal wave, so the public concluded that the bombs were not so very powerful after all. I boarded many of the target ships after each test; and I should not be inclined to disparage the effectiveness of the bomb. Fighting ships and auxiliaries alike, even at considerable distances, showed evidence of a terrific beating. It is true that a rather small fraction of the total number of target vessels was sunk; but the energy liberated in the blast was obviously enormous. When a single bomb can sink a group of near-by fighting ships and damage others at large distances, it is no dud. It is so far out of the class of conventional bombs that there can be little comparison. The remarkable thing is that the majority of the ships stood up so well under the beating they evidently received. Naval architecture will certainly feel some effects of the bomb tests; but the changes may not be so drastic as some have predicted.

As a weapon, atomic energy is a terrible thing. Perhaps it will be terrible enough, as many hope, to make war a thing of the past; I don't think so. I do feel certain that it cannot be successfully outlawed as a weapon; warring nations do not play a game and abide by sporting rules.

There is another side to nuclear energy, though; it is not pure devil. It can be successfully harnessed, and made to provide tremendous power for constructive peace time uses. But it will be for large power consumers, or for isolated outposts where other power sources are impractical; it will not directly heat your home or drive your car. An atomic power plant for the family automobile would require so much shielding material to protect the driver and passengers, as well as bystanders, that the result would be heavier and less maneuverable than our larger tanks. For large power plants the heavy protective walls are practical; but for small power output the cost would be excessive. There are other features, too, such as the disposition of radioactive by-products. For the large plant they can be overcome; but they pretty well eliminate the smallpower user. Nuclear energy does not provide a vest-pocket power source.

EVOLUTION OF THE TORPEDO

CAPTAIN WILLIAM S. WHITESIDE, U.S.N.

The idea and purpose of this talk is to go back into the years and show the evolution of the torpedo, starting with the fire ship of the first century filled with combustibles and maneuvering alongside the enemy. Then "Greek Fire" took over in the seventh century. The Byzantine empire ruled the seas and considered this method so vital that they kept the formula secret for over four centuries. Finally, the Saracens got hold of it and used it successfully against the Crusaders. Greek fire came in liquid form having a bitumen base carrying potassium kakodyl and chlorides of sulphur. It was served in bottles or jugs carrying lighted wicks which ignited the compound when containers broke inside enemy ships. Here we also see the first signs of chemical warfare and the incendiary bomb. Fire on shipboard was then the most feared of all hazards. It still is.

Then gun powder came out of the Orient and it was first used for the explosive charge of a floating mine in 1585, when at the siege of Antwerp, Lambellie, an Italian engineer, set adrift four flatboats each stowed with 7,000 pounds of black powder, to be exploded by a long sulphurated match-rope fuse. Only one of these flatboats exploded but the attempt was successful, for the bridge over the river Scheldt was demolished.

In the year 1628, at the siege of Rochelle, the English used the floating petards (a word meaning mine or torpedo) which was used by Shakespeare.

Navies of all nations, for a number of years after this period, used several types of floating mines. Some were small, having an explosive charge of but twenty pounds of gun powder; others were much larger, such as the huge mine of Saint Malo. This was a bark of 300 tons drawing nine feet of water. The hold was stowed with 20,000 pounds of gun powder covered with masonry. Old cannon, rocks, etc. were stowed on top of this. In 1695 this vessel (which was the largest floating mine in history) was sailed under the lee of Saint Malo. A long match was ignited giving the crew time to escape. The resulting explosion destroyed part of the city.

In 1770, the Russians sent two large floating mines against the Ottoman fleet which had been driven into the Port of Tehesma. The Ottoman fleet, as well as the fortifications, was destroyed from the shock.

To David Bushnell of Connecticut, an American engineer, is most certainly due the credit for inventing torpedoes, for in the year 1775, he was the first to prove that a charge of gun powder could be fired under the water, i.e., any ship could be sunk providing the charge of powder was large enough.

Bushnell also designed the first real submarine which actually navigated under service conditions and gave uncontestably valuable results. His little boat, which he was four years in building, had the form of a turtle; this shape was considered to give stability. She could hold only one man and could submerge for half an hour on the supply of air held in the boat.

A safety weight was placed at the lower extremity of the hull. This

weight was a mass of lead which served sa a ballast and could be released at will giving immediate positive buoyancy in an emergency.

The illustration, Fig. 1, shows the construction of Bushnell's submarine. It shows, secured to the stern of the vessel, the torpedo this craft carried. It consisted of 100 pounds of powder contained in a wooden case which was to be exploded by a clockwork mechanism, after the submarine was clear. This torpedo was intended to be secured to the bottom of an enemy vessel by means of a large screw that was manipulated from inside of the submarine.

Bushnell spent several months experimenting with the vessel and training the one man crew. This man was his brother Ezra Bushnell, who be-

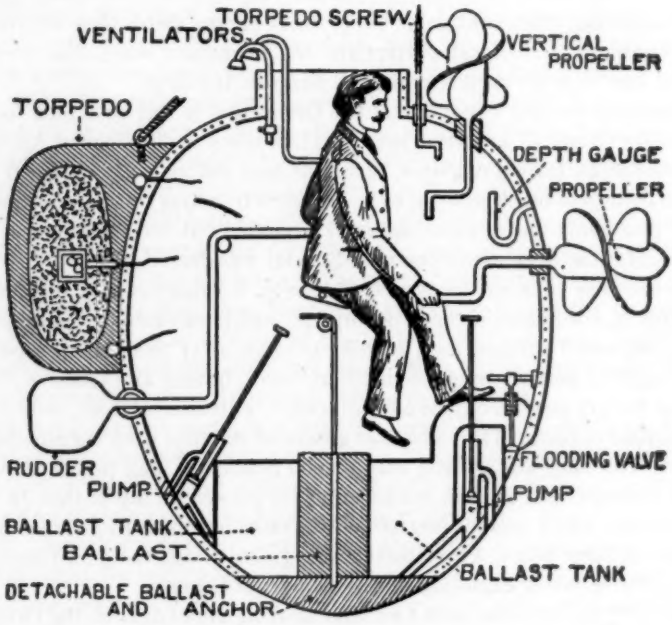


FIG. 1. Bushnell's Boat. 1775.

came very proficient in handling the boat. He was taken sick in the campaign of 1776 at New York before there was an opportunity to make use of his skill. Bushnell then trained Sergeant Ezra Lee, who made an attempt to sink the H.M.S. *Eagle* when she was anchored in New York harbor. This attack failed because the *Eagle's* bottom was sheathed with copper, and the screw by which the torpedo was to be attached would not penetrate this sheathing.

Bushnell also made several attempts to attack the enemy with his mine during our Revolutionary War. These mines were water-tight kegs of gun powder having negative buoyancy, supported a few feet below the surface

of the water by floats. Two kinds of fuses for the ignition of the powder were used. One was an ordinary gun lock fired by a spring on coming in contact with an obstacle; the other was fired by chemicals.

In the early part of 1777, Bushnell tried one of his mines on the British frigate *Cerberus*, which was then lying at anchor near New London, Connecticut. The *Cerberus* was lucky for she had a captured schooner alongside. The mine sank the schooner, but did not damage to the frigate.

In December, 1777, Bushnell tried out his kegs in an attempt to destroy the English Fleet anchored at Philadelphia. He constructed several of his floating keg torpedoes at Bordertown. His plan was to set them adrift in the Delaware River just above Philadelphia, at ebb tide so that the current would take them down against the vessels in the stream. To prevent the torpedoes from being discovered they had to be dispatched at night. This was done but bad luck was with Bushnell. He miscalculated the force of the current and at daylight the British discovered the mines and had small boats pick them up. One of the mines exploded destroying a boat and crew.

This affair was the cause of the humorous political essay that came out at this time called the "Battle of the Kegs." Nevertheless, the desired effect was achieved for it caused the English a great deal of alarm and they soon brought their fleet into safer waters.

Some years later the distinguished American inventor, Robert Fulton, followed up the experiments of Bushnell on about the same lines. During Fulton's time the French word "terpille" began to be used in connection with submarine explosive charges. In this country and in England the name torpedo was subsequently adapted. The term "torpedo" is derived from the electric rays (family torpedinidae). In common with the electric eel, these fish are frequently spoken of as torpedoes.

In 1800, Fulton built his first submarine boat in France. He built his second, a much better one, in 1801 called the *Nautilus*. In August, 1801, Fulton, by means of this submarine boat, attached a clock-work torpedo to the bottom of a vessel provided by the French government, for the experiment in the harbor of Brest, and destroyed her. This is the first vessel known to be destroyed by a torpedo. Notwithstanding Fulton's success, the French refused further aid and he went to England. Mr. Pitt, then Prime Minister of England, became very much interested in Fulton and greatly assisted him in bringing this invention before the public.

Fulton also designed a catamaran torpedo. These were oblong wooden vessels, 21 feet long and 3½ feet wide, shaped like huge coffins and floating just awash. The explosive charge consisted of 400 pounds of gun powder. On withdrawing a safety pin, a clock-work mechanism revolved for the set period, then a gun lock hammer was released striking a piece of flint and the resulting sparks caused an instantaneous explosion of the magazine.

The so-called "catamaran" expedition against the French fleet at Boulogne, October 2, 1804, was projected by Fulton and carried out by the British Admiral Lord Keith. Although this attack caused great excitement in the French fleet it was generally barren of results for the French flagship

ordered all the ships in the fleet to cut their cables to avoid the catamaran torpedoes. A dozen of these catamarans were set adrift with the tide and ten exploded with no damage as they did not come in contact with any vessel.

After several other experiments in England, Fulton came back to his own country. In 1810, a committee, constituted of United States Naval Officers, was appointed to investigate this enthusiast's latest inventions, particularly that of a harpoon torpedo (Fig. 2). This torpedo was intended to be discharged from a special type of musket, capable of being carried in an ordinary boat. The sharp point of this harpoon could penetrate the hull of any ship afloat, at this time. When this was fixed into the side of the enemy, the tide carried a float toward her. This supported a torpedo, which was swept into contact with her bottom, the impact being sufficient to release the spring gun-lock and so explode the charge.

To determine their effectiveness, the committee carried out experiments with the U. S. Frigate *Argus*. The defense of this ship was placed in the

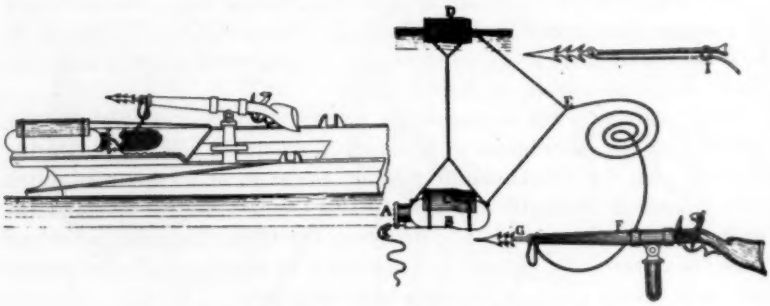


FIG. 2. Fulton's Harpoon Gun Torpedo. 1810.

hands of Commodore Rogers, who arranged to surround the vessel with booms, swinging spars armed with scythes, nets to touch the bottom, etc. This elaborate form of protection made it quite impossible for the frigate to be attacked effectively.

Fulton modestly acknowledged that the ingenuity of the Commodore in defending his vessel was greater than his in attacking it, but, at the same time, argued that "a system" which, only then in its infancy, compelled a hostile vessel to guard herself by such extraordinary means, could not fail to become a most important factor in war.

In commenting on the defense of the *Argus* the inventor further remarked, "The embarrassment which the Commodore threw in my way was not a defeat of torpedoes. It was only the defeat of the mode I practiced. As a brick wall 1 foot thick will stop a musket ball, but will not stop a 24 pound shot, it well might be said that defeating the musket ball proved gun powder was not as good as bows and arrows." With this parting sarcasm at the expense of the members of the committee, Fulton abandoned torpedo work and turned to marine steam propulsion.

Let us go back to 1804, when a large floating mine figured in one of the great heroic deeds of our navy. Commodore Preble, who at this time was attacking the Barbary pirates, selected the gallant little ketch *Intrepid* (the same vessel that Decatur had used in the burning of the *Philadelphia*). 15,000 pounds of powder were loaded in a compartment built about the mainmast. A long fuse, supposed to burn fifteen minutes before it reached the powder, was laid along the dock. On top of the powder was stowed 150 13″ and 9″ round shots. Preble determined to send the *Intrepid* to the base of the Bashaw's castle, ignite her, and let her explode against the palace walls. Commodore Richard Somars was appointed to command with Lieutenant Wadsworth as second in command. On September fourth, the *Intrepid* stood in for Tripoli with a crew of ten seamen and Somers, Wadsworth and Lieutenant Israel, who had joined at the last minute. The *Argus*, *Vixen* and *Nautilus* escorted her. Presently she left her excort and soon afterwards the noise of the cannonade was heard announcing her discovery. Suddenly there was a great light. For a long distance the mast and spars of the ketch appeared in the heart of the towering flame. Then there was darkness and the cannonading died away. The gallant *Intrepid* had been blown into small bits.

We now come to what can be termed the "Second epoch" in the evolution of the torpedo. In the year 1829, Colonel Colt, then a young man, commenced experiments with his submarine battery. His first successful experiment occurred in March, 1842, when he exploded a case of powder in New York harbor electrically. On the fourth of July of that same year he destroyed the old gun boat, *Boxer*, lying opposite Castle Garden, creating great excitement among the spectators. The government immediately offered him a schooner on the Potomac River to destroy if he could. On the 20th of August, 1842, in the presence of the President, heads of departments and General Scott, he utterly destroyed the schooner while stationed about five miles away. Congress voted him a grant of $17,000 to still further perfect his apparatus with which he made several other experiments. Only one of these experiments will be mentioned here—that is the destruction of a 500 ton brig, on the Potomac River, April 13, 1843. After her crew had abandoned her she was still under way and sailing at the rate of five miles an hour. Colonel Colt was the operator who was stationed at Alexandria, five miles away. This is the last recorded experiment of Colonel Colt with the so-called torpedo.

It seems incredible that our government let this far advanced method of warfare lie dormant for a number of years. Even the records were lost. Probably the reason for this was due to the sentiment of the people at this time, which was expressed by the President, John Quincy Adams, when he said that the use of submarine mines was a "cowardly and dishonest weapon in warfare." This sentiment was, also, shared by the civilized nations of the world up to the period of the Civil War. Even at the start of this war the Federal Government thought it was dishonorable to use this

method of warfare, but after the Confederates began using it successfully, the Federals followed suit.

In a long period of time starting from 1843, when Colonel Colt made his last successful experiment, up to almost the conclusion of the Civil War, this brilliant invention was as dead as the "Dodo." It was only after the use of numerous inefficient mines up to and near the end of the war that electric mines were used by the Confederates, for it was their harbors that needed this protection. From this period on, principally, due to the fact that the prejudice against this mode of warfare was not so keen, the explosive engineers, both in this country and abroad, began to perfect the system of electric mines we have today.

Going back again to 1854–1856, during the Crimean War, the Russians used submarine mines against the allied forces, principally in the defense of their harbors of Sebastopool, Streaborg, and Gronstadt. These were invented by Professor M. Jacobi, an eminent Russian chemist and philosopher. They were of the mechanical type, containing but 25 pounds of gun powder. A chemical fuse was provided for obtaining ignition. This consisted of a glass tube containing sulphuric acid, which on being shattered, allowed the liquid to fall on chlorate of potash causing flame due to chemical change. By this means the explosion of the whole charge was assured. One of these mines was exploded under the British ship *Merlin*, but owing to the small amount of explosive used, there was no damage beyond a severe shaking up.

Five years later, during our Civil War, a few of the casualties, caused by submarine warfare will bear a short repetition. In December, 1862, Admiral Porter ordered the Federal gun boats to enter the River Zasoo and attack Vicksburg. Many torpedoes were observed, most of which were sunk by gun fire, but the gun boat *Cairo* hit two torpedoes and then sank in twelve minutes. These torpedoes were merely demi-johns filled with powder and ignited by a common friction primer. They were secured in pairs 20 feet apart with a line, each end of which was secured to a friction primer of the mine. Captain Mahan, U.S.N., writes, in connection with this incident, "Torpedoes had hardly come to be looked upon as a respectable mode of warfare, especially by seamen, and the Confederate officer who laid these mines was looking on when the *Cairo* went down." He described himself as feeling much as a school-boy might whose practical joke had taken a more serious shape than he expected.

In the attack on Mobile, August 5, 1864, the Federal Navy had to contend with the forts protected by a line of pile obstructions leading to Dauphin Point, backed by a triple line of torpedoes in echelon. These torpedoes were of several kinds; one was made of well pitched beer kegs, filled with powder fitted with fine chemical fuses. Another type known as the Singer Torpedo, was constructed in the form of a truncated cone. A magazine of fifty pounds of powder was placed on the lower portion. On top was a cast iron weight so secured that a slight blow would cause it to fall off. This weight was held fast by a chain connected to a friction primer. As it

fell the weight pulled the friction pin, causing a flash which caused the charge to explode.

Admiral Farragut, in attacking the fortifications, placed his monitors first, led by the *Tecumseh* of 1034 tons, followed by the wooden ships. The *Tecumseh* had not gone very far into the danger zone when she contacted a submarine mine which violently exploded. The monitor lurched heavily and sank bow first. Captain Craven, with seventy of his officers and crew went down in this ill-fated vessel. The *Brooklyn*, seeing more dangers ahead, signalled to the flagship, *Hartford*, telling her that there were more torpedoes ahead. Admiral Farragut on receiving the signal, coined one of the great slogans in the traditions of our Navy. "Damn the torpedoes. Captain Drayton; go ahead, Jouett, full speed." Men in the hold of some of the ships actually felt and heard the torpedoes bump then graze along the bottom of the vessel. Fortunately, for the intrepid Admiral, long immersion in salt water had caused excessive corrosion of the metal portion of the mines, which prevented the firing mechanism from working effectively.

On May 6, 1864, the large and heavily armored Federal gun boat *Commodore Jones* was literally blown to fragments by an electric torpedo containing 2,000 pounds of powder. Nearly all on board were killed or, wounded. This disaster is particularly interesting in the history of submarine warfare, it being the only instance where the large electric torpedoes were successfully employed up to this time.

One more incident will be mentioned and that is the lucky escape of the *New Ironsides* during the attack at Charleston, April 7, 1863. She lay for a full hour over one of these huge electric mines. The Confederate officers stationed there could not have placed the ship better themselves for her destruction, for due to a defect in the mine, it failed to explode.

In all, some seven monitors and eleven wooden vessels were totally destroyed, while actively engaged in blockade work, by submarine mines. In passing, it may be noted that not a single vessel was lost by gun fire during this war. The same almost holds true today for there have been but few ships that have not been damaged or sunk by submarine warfare or aerial bombs.

We now come to the third epoch in the history of the torpedo, describing briefly the evolution of the movable torpedoes.

The term "torpedo" as applied to the defensive mines described in the first and second epoch is a misnomer. It is far more applicable to the offensive torpedo, the first of which was the spar torpedo used by both Federal and Confederate Navies. It consisted of a metal case containing from 40 to 100 pounds of powder which was carried at the end of a spar or outrigger projecting from a boat or vessel. The firing arrangements were either a gun lock with a percussion cap fired by a pull of a line attached to the trigger, or a chemical fuse which shattered when the charge hit the ship. Steam launches had this torpedo fitted so that it could be lowered well

beneath the water line of the enemy. Several vessels on both sides were sunk or damaged by this method.

Only one incident will be related here and that is one of the great historic deeds of the Civil War. This was the sinking of the Confederate ram *Albermarle* by Lieutenant Cushing, U.S.N., who in his official report stated, "The light of a fire ashore showed me that the ironclad made fast to the wharf surrounded by a pen of logs about thirty feet from her sides. We made for our enemy at full speed. In a moment we had struck the logs just abreast of the quarter-port, the bow of our launch resting on top of the logs. The torpedo boom was then lowered and by a vigorous pull of the lanyard, I succeeded in lowering the torpedo under the overhang, exploding it at the same time the *Albermarle's* gun was fired. A shot seemed to go crashing through my boat and a dense mass of water rushed in filling the launch, therefore completely disabling her. The enemy then continued his fire at point blank range and demanded our surrender, which I refused, ordering the men to save themselves. The most of our party were captured, some were drowned, and only one beside myself escaped." Note, the spar torpedo was in use by our Navy as late as 1890, when gun cotton was used as an explosive charge which fired by an electric detonator.

After the Civil War, inventors, in our country and abroad, were working on various types of moveable torpedoes but only a few will be mentioned in brief.

The first torpedo apparatus supplied to men of war of the different nations for use when the ships were in motion were known as towing torpedoes. The one most extensively used was designed jointly by Captain John Harvey and Commander Frederick Harvey, of the Royal Navy, known as the Harvey towing torpedo. It consisted of a sheet copper case, in two sizes, one to contain 76 pounds of rifle fine grain powder and the other, 27 pounds. Gun cotton could also be used. In order to maneuver with this weapon from a ship a speed of about six knots was required. The torpedoes were towed in pairs. The form was similar to the paravanes that men of war use today in clearing mine fields. When towed at a distance of 150 yards or so, this boat-like torpedo, having a fixed rudder, would diverge from the ship's quarters at an angle of about 45 degrees. On coming in contact with the enemy the charge was fired either electrically or by a chemical fuse. These were in use by all navies from 1870 to 1880. They were never tried out in war and were soon replaced by much more efficient torpedoes.

Ericsson, the famous inventor of the *Monitor*, designed two torpedoes, one in 1875 and the other in 1877. They were much alike, one having a rubber tube 400 yards long on a real astern of the firing ship, the other had this tube inside of the torpedo which unreeled as the torpedo went ahead. They were both propelled and steered by compressed air from an air compressor on the firing ship. The speed of these Ericsson torpedoes was only about four knots so they did not prove successful.

At about this time several torpedoes came into the picture. They were

electrically controlled and driven and each had negative buoyancy and were supported by a float. Only one of these will be briefly mentioned here That is the Sims-Edison electric torpedo of 1889. It carried a large reel of insulated wire two miles long that unreeled as the torpedo went ahead. The electric current for its control was generated by a dynamo aboard ship or on shore.

NOTE: From this time on torpedo engineers, of all maritime nations, experimented with various kinds of electrically controlled torpedoes including such as the Hammond air driven, radio controlled torpedo that came into the picture in 1930. Also, the Germans, during World War II, had a modern air driven torpedo for some of their harbor protection that had a large reel of insulated wire within the torpedo and it could be perfectly controlled and fired electrically.

We now come to a very interesting chemical torpedo. The Lay, designed in 1872 by a man whose name it bore. It was surface running, 23 feet long, 28 inches in diameter, weighing 1½ tons, with a war head carrying 300 pounds of dynamite. The propelling mechanism was a reciprocating engine operated by super-heated carbonic acid gas. It had a speed of 16 knots, with a range of two miles, the length of the two controlling cables. These cables were carried wound on a reel within the torpedo and unreeled as the torpedo went ahead. They led to the control ship or station. One cable controlled the electric steering engine; the other, the stop and starting mechanism. It was extensively experimented with at the Naval Torpedo Station, Newport, Rhode Island, from 1873 to 1880.

It was never used by our Navy but the Russians thought so well of it that they had Mr. Lay and some of his best mechanics go to Russia and establish a factory there. The Russian government used them for their harbor protection for several years, up to about 1890.

Now that the rocket, developed in World War II, has become one of the most formidable weapons in warfare, and will be more so in the future, it will be of more than passing interest to go back into the history of rocket torpedoes.

In 1862 Major Hunt of the Engineer Corps, U. S. Army, designed a "rocket" torpedo and a rocket gun, made of bronze, 12 inches in diameter. The muzzle of the piece projected through the firing ship's side several feet below the water line. The rocket torpedo was three feet long. The war head was filled with gun powder, abaft of which was the flask containing the pyrotechnic mixture which was ignited by an electric detonator. Major Hunt conducted extensive experiments with his torpedo at Red Hook, New York Harbor, but unfortunately he was killed by one of them, and no further experiments were made.

In 1873 Lieutenant F. N. Barber, U.S.N., stationed at the Naval Torpedo Station, Newport, Rhode Island, designed a rocket torpedo to be fired from a submarine tube. Its length was 7 feet, diameter 1 foot, weight 287 pounds (Fig. 3). The explosive charge in the war head was either powder or dynamite, weighing 48 pounds. The rocket charge of 51

pounds was contained in an iron tube ½ inch thick, surrounded by a layer of asbestos. Around this was a spiral tube (Fig. 3) made of light metal, capable of containing 52 pounds of sea water. At its forward end was a small valve which admitted sea water to replace the weight of the rocket mixture as it burned. The outside was made of oak and was rippled. The tail piece carried a percussion needle cartridge which fired the rocket mixture when the torpedo was ejected from the tube. This ejection was accomplished by compressed air.

In the seventies and eighties there were a dozen or more rocket torpedoes designed; torpedo engineers then being as rocket minded as they are now. Only one more rocket torpedo will be mentioned here and that is the very interesting Cunningham rocket torpedo designed in 1893 and 1894. Mr. Cunningham was a shoemaker from New Bedford, Massachusetts. His

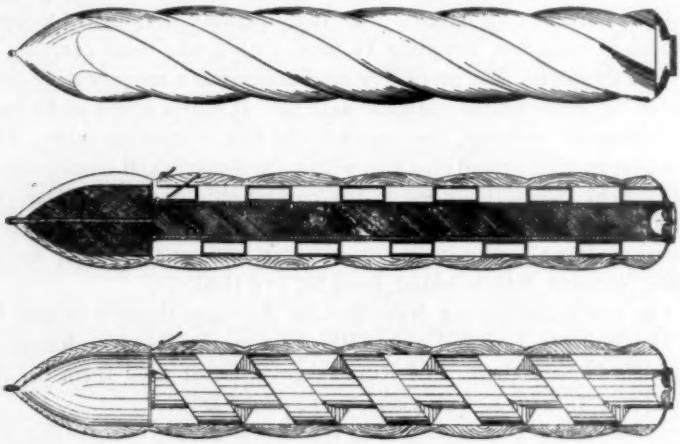


FIG. 3. Barber's Rocket Torpedo. 1873.

torpedo was tested for several years at the Naval Torpedo Station, Newport, R.I., and was fired from a submerged tube, but it did not get out of the experimental stage.

As this talk has been rather dry, I do not think that it will be amiss to inject a little humor. Mr. Cunningham, known to his friends as the "Wild Irishman," took one of his rocket torpedoes home with him and on the Fourth of July, 1897, he decided to have a real celebration. He rolled his rocket torpedo out into the road in front of his house and touched it off. It took off down the road, several horses ran away, people jumped clear of it, and then it smashed into a butcher shop, knocking the chopping block to bits and winding up in the icebox where it caused quite a fire.

We now come to the fourth and last epoch in the evolution of the torpedo. For convenience, a short history of the Howell torpedo will be written first although it was designed later than the Whitehead.

In 1870, Lieutenant Howell, later Admiral, U.S.N., began to experiment with this torpedo. He worked on it for nineteen years both at sea and at the Torpedo Station until 1889, when he perfected it. This torpedo was used by our Navy for a period of about ten years (1890–1900). The old battleships *Maine, Massachusetts, Indiana* and *Oregon* each had a torpedo tube in the eyes of the ship. The Howell torpedo was fired by a powder impulse. It had a range of 400 yards with an average speed of 25 knots. The main point of interest is that it did not have an air flask, the propeller power being a 132 pound fly-wheel spun to 10,000 R.P.M. by means of a steam turbine secured to the torpedo tube. The fly-wheel also acted as a huge gyroscope, keeping the torpedo on its lateral course. Its depth was controlled, as in all modern torpedoes, by a hydrostatic piston and pendulum. Another point of interest is its two $5\frac{1}{2}$ inch propellers that changed their pitch during the run. As the speed of the fly-wheel decreased, the pitch of the blades was mechanically changed, thus giving the torpedo a constant speed. It carried a charge of 100 pounds of gun cotton in its head.

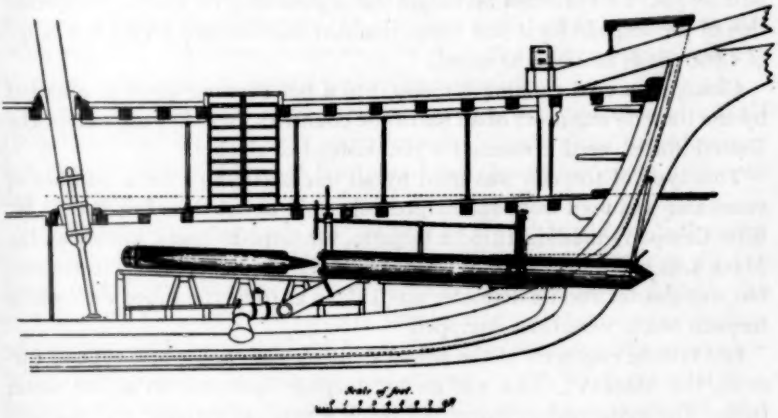


FIG. 4. The Lupis-Whitehead or Fish Torpedo. 1869.

In 1864 an Englishman, Mr. Whitehead, began to experiment with the fish torpedo, as it was then called. Later it was named after the inventor. When he started to manufacture them at Woolwich, England, in 1869 (Fig. 4), a new weapon of war came into existence that had all the fundamental principles of the modern torpedoes of today. It was the first self sustained torpedo and the one that finally survived all others. It was used by all the navies of the world for a number of years. In fact, the English have, today, a long range Whitehead torpedo as the Germans also have, but they changed the name to "Schwartzkopf." It is not the purpose of this article to go into the details in the operation of a torpedo with its hundreds of intricate parts. It is sufficient to say that this Whitehead torpedo used compressed air (contained in a strong steel flask) for the motive power of a reciprocating engine driving two propellers. The torpedo

could be adjusted to run at a set depth and it was controlled laterally by a gyroscope. A warhead, secured to the forward end of the air flask, contained the explosive charge of gun cotton. (TNT is used today.)

The first Whitehead torpedoes used by our navy during the nineties, were bought from the Whitehead Company in Woolwich, England. They had a range of 800 yards and, at that range, a speed of 27 knots.

In 1901, the E. W. Bliss Company of Brooklyn, New York, bought the rights from the Whitehead Company to manufacture their torpedoes and, for a number of years, manufactured the torpedoes used by our Navy.

These torpedoes had the essential features of the English Whitehead and they were all cold running, that is, their motive power was cold compressed air lead directly from the air flask to the reducer of the main engine.

In 1904 the torpedo engineer of the E. W. Bliss Company, Mr. Leavitt, designed a new torpedo known as the Bliss-Leavitt 21′ 21″. Its main engine was a vertical turbine. The air flask was compressed to 2250 pounds per square inch. This air was preheated by means of burning alcohol in a combustion pot. This brilliant invention was a great step forward in the evolution of the torpedo for it just about doubled its efficiency giving it a range of 4,000 yards at 27 knots speed.

Changing a cold running torpedo into a hot running one was adopted by the torpedo engineers of all maritime countries, but they all, except the United States, used kerosene for fuel instead of alcohol.

This type of torpedo was used by all our battleships for a number of years and was fired from submerged tubes. At about this time the E. W. Bliss Company manufactured a torpedo, for torpedo boats, known as the Mark 4. It had all the essential features of the above battleship torpedoes, but was shorter and its diameter was 18″, so as to fit the tubes with which torpedo boats were then equipped.

In 1910 the engineers of the Bliss Company designed a new type of torpedo, the Mark VI. This was an 18″ torpedo invented for above water tubes. The main engine, instead of being a vertical turbine, was changed to a horizontal turbine eliminating the bevel gears in the tail; it also eliminated the immersion chamber and combined the depth and gyro gear in one unit. It was a hot running torpedo and had a speed of 35 knots but to obtain this high speed the range was cut down to but 2,000 yards.

Only about fifty of this type of torpedo was manufacuated. The Bliss Company was then designing a very efficient torpedo which was again a great step forward in its evolution. This was the Mark VII, an 18″ torpedo with a length of 21′. It had the essential features of the Mark VI but a new feature was used which again doubled its efficiency giving it a range of 8,000 yards at a speed of 27 knots. This new feature was the introduction of fresh water into the combustion pot, which was turned into steam by the burning alcohol. This torpedo was known as a steam torpedo. The air flask pressure had also been increased to 2,500 pounds per square inch.

This improved torpedo was issued to the service in 1912 and its fundamental designed remained the same for 33 years, up to and including World War II.

The first recorded damage by torpedoes occurred on January 28, 1878. The Russian men of war *Tchesme* and *Sinape* each fired one Whitehead torpedo at a Turkish Revenue cutter, sinking her. The first known instance of a battleship being sun occurred on April 23, 1891, when the Chilena insurgent battleship *Vlanco Inclada*, while anchored in Caldua Bay was attacked by two torpedo gun-boats belonging to the government. She was hit amidships by a Whitehead torpedo and sunk in six minutes, taking eleven officers and 171 men with her.

Torpedoes were also used effectively in a war between China and Japan (1895). The Japanese torpedo boats played a most important part, sinking four major ships. They were of the French pattern, with turtle-back decks. They were fitted with one torpedo tube in the bow and one training tube amidships, each carrying six Whitehead torpedoes having a range of 800 yards and at that range a speed of 27 knots.

Ten years later, in the war between Russia and Japan, the torpedo was again used very effectively by the Japanese torpedo boats, sinking four Russian battleships and three armored cruisers, and also severely damaging several other ships. Although the Russians had twenty torpedo boats, equipped with Whitehead torpedoes, they did not sink a single Japanese ship due principally to poorly trained personnel.

During our war with Spain (1898) torpedoes were not used at all, although the Spanish ships were equipped with Schwartzkopf torpedoes and our ships with the old type of Whitehead and Howell torpedoes. Only gun fire was used.

Torpedoes were used most successfully in World War I by both sides, the Germans sinking 1381 merchantmen with their submarines. In the battle of Jutland, England lost several of her major ships by torpedo fire as well as the Germans. Our country's major role in this submarine warfare was the laying of the great North Sea barrage, 74,000 of our Mark 6 electric mines were planted. It was the real answer to the German submarine menace and more than helped to bring the war to a successful conclusion.

In the late war (World War II) there is no doubt that the torpedo was the deadliest naval weapon.

We will always remember the fatal Sunday, December 7, 1941, when in a period of just a few minutes our magnificent fleet was sunk by Japanese torpedo planes.

The Germans, in the largest of all wars, came very near destroying the allied merchant marine, sinking thousands of ships with their torpedoes.

Torpedoes fired from our submarines and torpedo planes destroyed the major portion of the Japanese fleet and most of their merchant ships.

Remember that it was a torpedo launched from a plane that crippled the giant *Bismark*, ace of the German fleet, and enabled the avenging British ships to catch up with her. Also, that it was torpedoes that sank her after she had endured the worst pounding in the history by heavy guns and bombs, which failed to do so.

The British broke the back of the Italian fleet at Oran—again it was the

torpedo that sank the magnificent British battleships, the *Prince of Wales* and the heavy cruiser *Repulse* in the South China Sea.

Another striking example of the effectiveness of the torpedo is that of the two British aircraft carriers *Illustrious* and *Ark Royal*, which were practically sister ships. A swarm of Junkers dive bombers strafed the *Illustrious* for three hours one clear afternoon in the Mediterranean. They hit her flight and hangar decks squarely seven times with 2,000 pound bombs. She didn't sink and she was able to steam into Malta. Nazi bombers found her there and pasted her all over again. Still she was able to steam across the Atlantic for repairs. A single torpedo hit the *Ark Royal* and she sank.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago, Illinois

124. Literal Equations. Generalized Problems. Simple linear equations like $5x=10$, $x+6=13$, and $5x+4=19$ are treated early in any course in algebra. After treating these equations, many textbooks introduce at once (usually as optional work for the better pupils) equations like $ax=b$ or $x+c=d$. Likewise, throughout the text, when equations with parentheses or with fractional coefficients, or sets of equations, or quadratic equations are studied, the lists of exericises end with a few literal equations of the same type. Their position at the end of the list clearly indicates that the work is optional and not part of a minimum course.

This way of treating literal equations does not give the bright pupil a correct understanding of how mathematics regards literal equations. The pupil cau do the mechanical work of solving $x+a=b$ just as he solved $x+6=13$, but he does not learn why 6 should be replaced by a. The "minimum" pupils are evidently excused from this work on the assumption that it is too difficult, whereas actually it is easier to learn than some of the items in the minimum course.

Instead of this piecemeal treatment of literal equations I would omit these equations entirely until after the pupil has solved all the types of linear equations including those with parentheses and fractional coefficients and sets of equations. And I would wait until the class has a fair command of the verbal problems which lead to such equations. Then, at an appropriate time I announce that we are to study (a) *how* a prob-

lem is generalized, and (b) *why* a problem is generalized. We begin with the problem:

One machine can do a job in 8 hours; another machine can do the same job in 4 hours. How many hours are needed to do this job if both machines are used?

The class has already studied such problems often enough so that the customary wrong ideas have been eliminated, and a majority of the pupils find the answer quickly. We then solve the same problem substituting the numbers 20 and 15 for 8 and 4; and once more, substituting two others numbers for 8 and 4. Finally I suggest that it would doubtless be clever to find a formula from which we could tell the answer without doing so much work. In fact, there is such a formula; and I know it, and can give the answer to such a problem as quickly as any pupil can state the problem. Invariably some smart pupil proposes numbers like $17\frac{3}{4}$ and $257\frac{5}{8}$; at once I write the answer as

$$\frac{17\frac{3}{4}\times 257\frac{5}{8}}{17\frac{3}{4}+257\frac{5}{8}}.$$

The work has thus been motivated and we are ready to investigate how such formulas can be found.

Since we do not wish to use the specific numbers 8 and 4, nor the specific numbers 20 and 15, nor any other two specific numbers, I suggest using a for *any* number, and b for some other *any* number. The a and b are *general* numbers and are contrasted with *specific* numbers. Substituting general numbers for specific numbers in a problem is called generalizing the problem. The class should at once have some practice in generalizing problems. A pupil selects any verbal problem from any page of his text and substitutes a, b, c, and so forth, for the specific numbers.

The next step is that of solving the general problem. This is done by sending two pupils to the blackboard. The first selects any problem in his text and copies it on the board. The second pupil writes the generalization. Suppose the first pupil selects:

How many bushels of corn at 70 cents a bushel and of wheat at \$1.50 a bushel should be mixed to make 200 bushels of feed worth 90 cents a bushel?

The second pupil writes:

How many bushels of corn at a cents a bushel and of wheat at b cents a bushel should be mixed to make c bushels worth d cents a bushel?

The instructions to the pupils now are: The first pupil is to write his solution. The second pupil needs only a slight amount of brains. He does not even need to know how to solve his problem; he is merely to copy the work of the first pupil with this slight change: wherever the first pupil writes 70, the second pupil will write a; wherever the first pupil writes 150, the second pupil will write b, and so forth. The work is stopped when the first pupil has written the equation for his problem and the second has found his by the substitutions.

The class usually regards this procedure as good entertainment, and every pupil clamors to be the "second" pupil since he needs no brains and can put all the responsibility on the "first" pupil. The work so far requires about forty minutes, and so, for the next day's homework, the pupils are required to generalize some problems of their own choosing from the text.

At the beginning of the second day, the pupils write on the blackboard the equations which have been derived from their problems. This is done so that the class can see the variety and complexity, or simplicity, of the equations. The project for the second day is: how are the equations to be solved.

The class is pleased to hear that this is as simple as the first day's work. Again, a "second" pupil needs merely to imitate a "first" pupil who knows how to solve equations with specific numbers. A "second" pupil volunteers, but before he is sent to the board, I quiz him about a few simple matters:

What, for example, will he write if the first pupil writes $80+60$? Answer: $a+b$.

What will he write if the first pupil multiplies 4 by 3?

Answer: ab.

But, suppose the first pupil actually adds $3x$ and $2x$, writing $5x$? How can you add ax and bx? Sometimes the answer comes forth at once: $(a+b)x$. Usually some discussion of this addition is needed.

With the two pupils at the board, we begin with $5x=10$, and $ax=b$, and then proceed to $5+x=10$, $a+x=b$, and to $ax+bx=c$, and so forth until the class has learned the fundamentals. A day is usually spent on solving linear equations, first attacking those that the pupils had gathered from their own generalizations. The simpler sets of linear equations are also solved. Sooner or later some bright pupil points out that solving $ax+by=c$ and $dx+ey=f$ would produce formulas that would have saved the class countless hours of work earlier in the year, and "why

don't teachers tell the class all this at the beginning?" My usual answer is that I would have been glad to do so if the pupils could have understood and appreciated the process, and I suggest that they try teaching it next semester to any of their friends who may be entering high school.

It is not mere accident that this work was started with a "rate of work" problem. I tried various types and found that this problem gives the best results. For a second choice I would use the problem:

How many miles can I drive, if I go at the rate of 30 miles an hour, return at the rate of 50 miles an hour, and must make the round trip in exactly one hour?

As a further suggestion, I recommend the article by Josephine Wible in the November, 1945, issue of *The Mathematics Teacher*. This article points out how generalized problems have been neglected in beginning algebra and the use that can be made of them.

125. Learning to Present Material. Too much time is usually spent in the ninth grade on drawing graphs of lines; the topic is overrated in importance but is popular because it is easy to learn. However, the work can be used to teach neatness, orderliness, clearness of expression, good habits of presenting work, and such matters.

In most cases the pupil is satisfied to present the graph and a table of corresponding values used in plotting the points. The computations that he has done to get the table of values were done mentally or on scratch paper and then thrown away. After a pupil has learned to do this much, I assign an equation like $245x+357y=639$. I select large coefficients so that the computing cannot be done mentally, and I insist that 100% of the computing must be shown on the paper that he hands me. Further, he must arrange this adding, subtracting, multiplying and dividing in a neat way so that I can understand and see each step; it must be arranged alongside of the work, not collected at the end of the problem or on a separate paper. When he uses $x=-3$ and finds a corresponding value of y, he must include the words "if" and "then" as in the statement:

If $x=-3$, then

$$y=\frac{639-245(-3)}{357}=\text{etc.}$$

He must plot at least 3 points, as a check on the position of

the other two. And when the work is handed in, I try my best to find some fault with it so that he can do the job again even if the improvement is only a slight one. Naturally, the class wants to be told explicitly what should be done; but I tell the pupils that I prefer to let them have the fun of planning and organizing the entire job.

Pupils can profit by allowing them to examine the work of other pupils. Hence, when the job is finished, the papers are passed in rotation from pupil to pupil, and each pupil is encouraged to note the good and bad points in the other fellow's organization.

When I say that the drawing of graphs is overrated I do not mean to imply that the topic should be omitted. The drawing of several graphs on one set of axes and the use of graphs to solve an entire group of problems (see these Notes, Feb., 1945) is an important topic. Too few pupils get that far.

OIL, SOIL AND METALLIC ORES

Oil, soil and metallic ores, three primaries in the life of a modern nation, received first attention at the Conference on Engineering and Human Affairs held here in connection with the bicentennial celebration of Princeton University.

The oil situation was summarized by J. E. Pogue, vice president of the Chase National Bank. Inventory-taking as applied to mineral deposits, he stated, evaluates known reserves and methods of extraction, but not technological progress that enlarges output.

This technologic factor, he said, has improved the art of oil finding, enlarged the scope of discovery by giving access to greater depths, increased percentage of recovery from the ground, and greatly enhanced recovery of gasoline from crude oil.

No modern nation can support its complex culture without trade in minerals, declared Donald H. McLaughlin, president of the Homestake Mining Co. Metals for machines, tools and structures are the basic materials required. Even the violation of the atom by clear physicists is not likely to free us from this dependence on ores.

THE TEACHER SHORTAGE

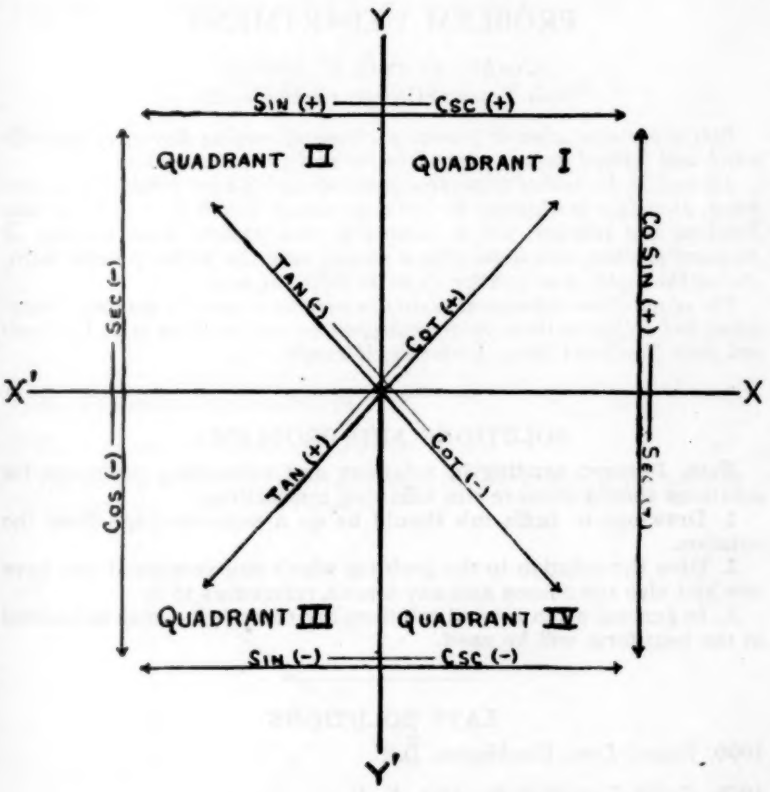
The acute teacher shortage of the war years is stretching on into the postwar period. This was bound to happen because young people were not preparing for the teaching profession in adequate numbers during the war. And they are not doing so now. Primary reason is the wage differential as compared with salaries in other fields. For example, the minimum professional salary in the federal service is now $2645. The average for all professional workers in the federal government is $4150 as compared with $2000 for teachers. A profession, one-half of whose number receives less than $2000, no longer can attract or hold capable people.

THE SIGNS OF THE TRIGONOMETRIC FUNCTIONS OF ANY ANGLE

(A Mnemonic Device)

GRACE MARIE COLEMAN*
Wiley College, Marshall, Texas

In the accompanying figure, the attempt has been made to illustrate a device which I have found convenient in memorizing the signs of the six trigonometric functions for the four quadrants. Most students are able to retain an illustration easily



once they have a picture of it in mind. For this reason, it has been of benefit to me.

An explanation of the figure is the following: Each double arrow gives the two functions or reciprocal relations involved;

* The writer is beginning a major in the field of mathematics at Wiley College, Marshall, Texas.

the two quadrants related in the device; and the *signs* of the relations or functions for the two quadrants. For example, the lower horizontal double arrow of the diagram means that the *sine* and *cosecant* have *negative values* in the *third* and *fourth quadrants*. In other words, the indicated signs affect only the two quadrants within the range of the arrows.

The figure eliminates the time used in calculating the functional signs of the four quadrants and the time saved can otherwise be used to advantage in a quiz that has to be completed within a limited period of time.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1990. *Russell Lane, Washington, D. C.*

1988. *Philip Rosenblatt, Brooklyn, N. Y.*
Paul Mouert-Campbell, New Mexico Military Institute.

1993. *Proposed by Hugo Brandt, Chicago.*

Find an expression for the sum of the series:

$$s = x + \frac{x^3 \cdot 5}{1!8} + \frac{x^5 \cdot 7 \cdot 9}{2!8^2} + \frac{x^7 \cdot 9 \cdot 11 \cdot 13}{3!8^3} + \cdots$$

and evaluate it for $x=.96$.

Solution by the proposer

Solution: Modify the denominators, say, 318^3 as follows

$$1\cdot 2\cdot 3\cdot 8^3=2\cdot 4\cdot 6\cdot 8^3$$

$$=\frac{7!8^3}{1\cdot 3\cdot 5\cdot 7}$$

$$\therefore\quad \frac{x^7\cdot 9\cdot 11\cdot 13}{318^3}=\frac{x^7}{7!}\cdot\frac{1}{2}\cdot\frac{3}{2}\cdot\frac{5}{2}\cdot\frac{7}{2}\cdot\frac{9}{2}\cdot\frac{11}{2}\cdot\frac{13}{2}\cdot 2$$

$$\therefore\quad s=2\,\frac{x}{2}+2\,\frac{x^3}{3!}\,\frac{1}{2}\cdot\frac{3}{2}\cdot\frac{5}{2}+2\,\frac{x^5}{5!}\,\frac{1}{2}\cdot\frac{3}{2}\cdot\frac{5}{2}\cdot\frac{7}{2}\cdot\frac{9}{2}+\cdots.$$

This may be represented as the difference of the two series.

$$s_1=1+\frac{x}{2}+\frac{x^2}{2!}\cdot\frac{1}{2}\cdot\frac{3}{2}+\frac{x^3}{3!}\,\frac{1}{2}\cdot\frac{3}{2}\cdot\frac{5}{2}+\cdots=\sqrt{\frac{1}{1-x}}$$

and

$$s_2=1-\frac{x}{2}+\frac{x^2}{2!}\cdot\frac{1}{2}\cdot\frac{3}{2}-\frac{x^3}{3!}\cdot\frac{1}{2}\cdot\frac{3}{2}\cdot\frac{5}{2}+\cdots=\sqrt{\frac{1}{1+x}}$$

$$\therefore\quad s=\sqrt{\frac{1}{1-x}}-\sqrt{\frac{1}{1+x}}.$$

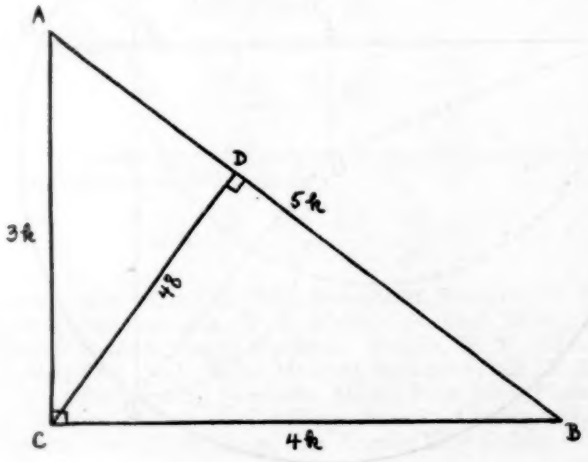
For

$$x=.96, s=5-\frac{5}{7}=4\frac{2}{7}.$$

1994. *No solution has been offered.*

1995. *Proposed by Ollie Raeder, Fayette, N. Y.*

The sides of a triangle are proportional to 3, 4, and 5. If the altitude to the longest side is 48, find the area.



Solution by Philip Rosenblatt, Brooklyn, N. Y.

Since its sides are proportional to 3, 4, and 5, $\triangle ABC$ is a right triangle, and its area is $\frac{1}{2}(4k)(3k) = 6k_2$.

$$\triangle CDB \sim \triangle ABC$$

$$\therefore \quad \frac{48}{3k} = \frac{4k}{5k} = \frac{4}{5}$$

$$12k = 240$$

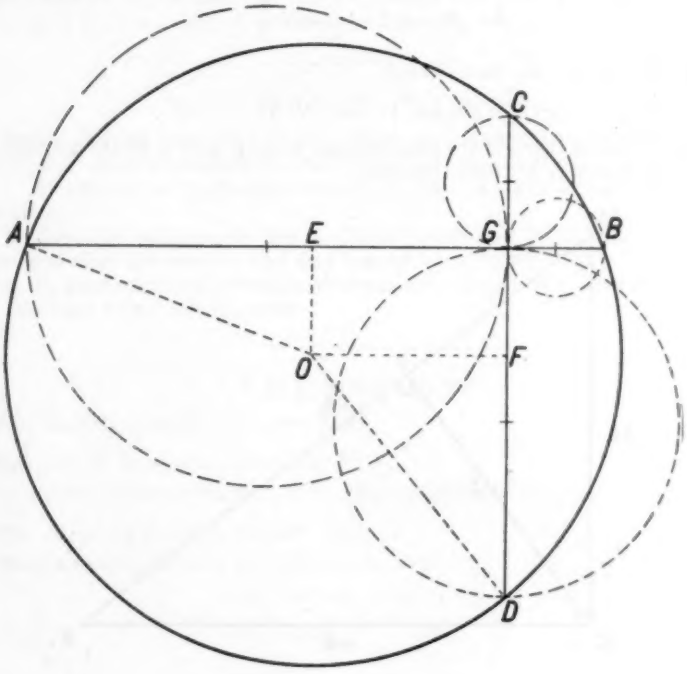
$$k = 20$$

Hence, Area $= 6k_2 = 2400$.

Solutions were also offered by F. L. Maxwell, Greer, S. C.; Paul Mont-Campbell, New Mexico Military Institute; Helen M. Scott, Baltimore, Md.; Jon S. Peters, Ryderwood, Wash.; R. J. Hoyle, Turloch, Calif.; Hugo Brandt, Chicago; Olive Bogardus, Lynchburg, Va.; Walter R. Warne, University of Dayton, Dayton, Ohio; J. X. Brennan, Atlanta, Ga.; Felix John, Philadelphia, Pa.; John P. Esposito, Chicago; Margaret Joseph, Milwaukee, Wis.; Orville A. George, Mason City, Iowa.; D. F. Wallace, St. Paul, Minn.; A. Riccio, Keewation, Minn.; Hazel S. Wilson, Annapolis, Md.; Aaron Buchman, Buffalo, N. Y.; Peter Van Riper, East Varick, N. Y.; William Redsfield, McDuffietown, N. Y.; C. W. Trigg, Los Angeles City College.

1996. *Proposed by Lucy Reigle, Sampson, N. Y.*

Two chords of a circle meet at right angles. Show that the sum of the four circles drawn on the four segments of the chords as diameters is equal to the area of the given circle.



Solution by Paul Mount-Campbell, New Mexico Military Institute

It is given that AB and CD are perpendicular chords of the circle with center at O.

The object is to prove that the area of the circle with center at O is equal to the sum of the areas of the four circles whose diameters are the segments AG, BG, CG, and DG. That is, we must prove that

$$\overline{AC}^2=\frac{\overline{AG}^2}{4}+\frac{\overline{BG}^2}{4}+\frac{\overline{CG}^2}{4}+\frac{\overline{DG}^2}{4}. \tag{1}$$

EO and OF are perpendiculars drawn to AB and CD, respectively. Since perpendiculars crawn from the center of a circle to the chords bisect the chords, it follows that

$$\overline{AE}=\frac{\overline{AG}+\overline{BG}}{2} \qquad \overline{CG}+\overline{GD} \tag{2}$$

$$\overline{FG}=\frac{\overline{DG}-\overline{CG}}{2}, \quad \text{since} \quad FC=FG+GC=\frac{CG+GD}{2}. \tag{3}$$

Since FO and EG are each perpendicular to CD and lie in the same plane, they are parallel. In like manner FG is parallel to EO. FG is equal to EO because parallels included between parallels are equal. Therefore (3) becomes

$$\overline{EO}=\frac{\overline{DG}-\overline{CG}}{2}. \tag{4}$$

In the right triangle AEO

$$\overline{AO}^2=\overline{AE}^2+\overline{EO}. \tag{5}$$

Substitute (2) and (4) in (5) and rearrange the terms

$$\overline{AO}^2=\frac{\overline{AG}^2}{4}+\frac{\overline{BG}^2}{4}+\frac{\overline{CG}^2}{4}+\frac{\overline{DG}^2}{4}+\frac{\overline{AG}\cdot\overline{BG}}{2}-\frac{\overline{CG}\cdot\overline{DG}}{2}. \tag{6}$$

When chords intersect, the product of the segments of one is equal to the product of the segments of the other; thus it follows that

$$\overline{AG}\cdot\overline{BG}=\overline{CG}\cdot\overline{DG},$$

and by dividing both sides by 2, we get

$$\frac{\overline{AG}\cdot\overline{BG}}{2}=\frac{\overline{CG}\cdot\overline{DG}}{2}.$$

Therefore the last two terms of number (6) may be removed since their algebraic sum equals zero. We then have

$$\overline{AO}^2=\frac{\overline{AG}^2}{4}+\frac{\overline{BG}^2}{4}+\frac{\overline{CG}^2}{4}+\frac{\overline{DG}^2}{4}. \qquad \text{Q.E.D.}$$

Solutions were also offered by Philip Rosenblatt, Brooklyn, N. Y.; Margaret Joseph, Milwaukee, Wis.; D. F. Wallace, St. Paul, Minn.; Hazel S. Wilson, Annapolis, Md.; Aaron Buchman, Buffalo, N. Y.; Abraham L. Epstein, Asbury Park, N. J.; Helen M. Scott, Baltimore, Md.; R. J. Hoyle, Turloch, Calif.; Tom Roach, Dearborn, Mich.; Felix John, Philadelphia, Pa.; F. L. Maxwell, Greer, S. C.; Hugo Brandt, Chicago; Walter R. Warne, Dayton, Ohio; C. W. Trigg, Los Angeles City College.

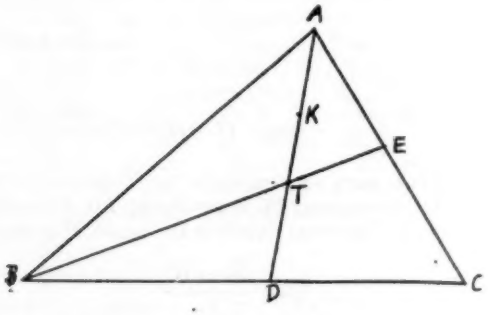
1997. *Proposed by Hugo Brandt, Chicago.*

In any triangle ABC, if AD is the bisector of A, with D on BC, and if points T and K divide DA so that $DT:TK:KA=a:b:c$, then T is the incenter.

Solution by D. F. Wallace, St. Paul, Minn.

Through T draw BE meeting AC at E. Using BE as a transversal of $\triangle ABC$, we have:

$$\frac{AT}{DT}\cdot\frac{DB}{CB}\cdot\frac{CE}{AE}=1. \tag{1}$$



By hypothesis $DT:TK:KA=a:b:c$

$$\therefore\quad \frac{AK+KT}{DT}=\frac{b+c}{a}=\frac{AT}{DT}.$$

Since AD bisects $\angle A$:

$$\frac{DB}{CD}=\frac{c}{b}.$$

$$\therefore\quad \frac{DB}{CD+DB}=\frac{c}{b+c}=\frac{DB}{CB}.$$

Substituting in (1)

$$\frac{b+c}{a} \quad \text{for} \quad \frac{AT}{DT}$$

and

$$\frac{c}{b+c} \quad \text{for} \quad \frac{DB}{CB}$$

we have:

$$\frac{b+c}{a}\cdot\frac{c}{b+c}\cdot\frac{CE}{AE}=1,$$

or

$$\frac{c}{a}\cdot\frac{CE}{AE}=1. \tag{2}$$

Multiplying both members of (2) by AE/CE we have

$$\frac{c}{a}=\frac{AE}{CE}$$

$\therefore BE$ bisects $\angle B$

$\therefore T$ is the incenter of $\triangle ABC$ *Q.E.D.*

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; Walter R. Warne, Dayton, Ohio; Edith M. Warne, Dayton, Ohio; Hugo Brandt, Chicago; B. Felix John, Philadelphia, Pa.; Helen M. Scott, Baltimore, Md.; C. W. Trigg, Los Angeles.

1998. *Proposed by Grace Smith, McDuffietown, N. Y.*

Divide 316 into two parts so that one part is divisible by 13 and the other part by 11.

Solution by M. M. Dreiling, Collegeville, Indiana

Let

$$x+y=316$$

and

$$x/13=a, \qquad y/11=b,$$

$$13a+11b=316,$$

$$b=\frac{316-13a}{11}=28-a+\frac{8-2a}{1}.$$

If b is to be an integer when a is one, then

$$\frac{8-2a}{11}$$

is one, say u

$$\therefore \quad u=\frac{8-2a}{11} \quad \text{or} \quad a=\frac{8-11u}{2}=4-5u-\frac{u}{2}.$$

If a must be an integer, then $-u/2$ must be an integer, say 1, $\therefore u=-2$

$$\therefore \quad a=15 \text{ and } b=11, \quad \text{and} \quad x=195 \text{ and } y=121.$$

Now, equation $13a+11b=316$ is of the form $ax+by=c$, where a, b, c are integers with no common factors, and has, therefore, integral solutions. If $x=r$ and $y=s$ be one integral solution, then all of its integral solutions are given by the formulas

$$x=r+11t \quad \text{and} \quad y==11-st$$

when all possible values are assigned to t. In our case, therefore, we have

$$a=15+11t,$$

$$b=11-13t.$$

With $t=0$ and -1 we obtain the only possible positive values of a and b, namely, 15, 4 and 11, 24 respectively. Therefore $x=195, 52$ and $y=121, 264$.

Solutions were also offered by Philip Rosenblatt, Brooklyn, N. Y.; R. J. Hoyle, Turloch, Calif.; Helen M. Scott, Baltimore, Md.; E. de la Garza, Brownsville, Texas; Hugo Brandt, Chicago; Edward Brooks, Philadelphia, Pa.; B. Felix John, Philadelphia, Pa.; L. R. Galebaugh, Lebanon, Pa.; W. R. Smith, Suttons Bay, Mich.; Orville A. George, Mason City, Iowa; Hazel S. Wilson, Annapolis, Md.; D. F. Wallace, St. Paul, Minn.; Aaron Buchman, Buffalo, N. Y.; C. W. Trigg, Los Angeles.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

1995. *Francis Trimberger, Arlynn Pilling and Betty Spannagle, Sheboygan (N. H. S.) Wis.; Don Danly, Washington, D. C.*

1996. *Allan West, Sheboygan (N. H. S.) Wis.; Don Danly, Washington, D. C., c/o Woodrow Wilson H. S.; Tom Roach, Dearborn, Mich.*

PROBLEMS FOR SOLUTION

2011. *Proposed by Hugo Brandt, Chicago.*

Let $FHKL$ be any quadrangle with A, B, C, D the centers of 4 squares erected on sides FH, HK, KL, LF respectively. Show that AC and BD are perpendicular to each other and that $AC = BD$.

2012. *Proposed by Martin Pearl, Brooklyn, N. Y.*

From an external point, P, two tangents are drawn to a circle at A and B. Secant PCD cuts the circle at C and D. Chord AB is drawn with midpoint M. CME cuts the circle at E. Prove DE is parallel to AB.

2013. *Proposed by Cecil B. Read, Wichita, Kan.*

An equilateral spherical triangle is inscribed in a given small circle on a sphere; an equilateral spherical triangle is circumscribed about the same small circle. Determine these triangles.

2014. *Proposed by Lillian A. MacDonald, Newark, N. J.*

If S_p is the sum of the p^{th} powers of the first n odd integers, show that $S_7 + 7S_5 + 7S_3 + S_1$ equals the fourth power of an integer.

2015. *Proposed by Hugo Brandt, Chicago.*

Find values of x to satisfy: $x^5 \equiv 1 \pmod{11}$.

2016. *Proposed by Helen M. Scott, Baltimore, Md.*

For the closed curve represented by

$$\left(\frac{x}{a}\right)^2 = \left(\frac{y}{b}\right)^{1/n} = 1,$$

where n is an integer, find the coordinates of the points of inflection.

FELLOWSHIP AWARD DEADLINE IS SET

Deadline for applications for the $1,500 postdoctoral Sigma Delta Epsilon fellowship at Wellesley for 1947–48 has been set for next Feb. 1. The award made by the graduate women's scientific fraternity is for research in the mathematical, physical or biological sciences.

BOOKS AND PAMPHLETS RECEIVED

CONCISE ANALYTIC GEOMETRY, by Charles H. Sisam, *Professor of Mathematics, Colorado College, Colorado Springs, Colo.* Cloth. Pages ix+155. 15×23.5 cm. 1946. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y. Price $2.00.

THE MAGIC OF NUMBERS, by Eric Temple Bell, Author of *Men of Mathematics.* Cloth. Pages viii+418. 13.5×20.5 cm. 1946. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.50.

THE ELECTRONIC THEORY OF ACIDS AND BASES, by W. F. Luder, *Associate Professor of Chemistry* and Saverio Zuffanti, *Associate Professor of Chemistry, Northeastern University, Boston, Massachusetts.* Cloth. Pages ix+165. 13.5×21 cm. 1946. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

COMMUNICATION THROUGH THE AGES, by Alfred Still, *Fellow, American Institute of Electrical Engineers; Member, Institution of Electrical Engineers.* Cloth. 201 pages. 14×21.5 cm. 1946. Murry Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $2.75.

SMITH'S COLLEGE CHEMISTRY, by William F. Ehret, *Professor of Chemistry, New York University, N. Y.* Sixth Edition. Cloth. Pages xii+677. 17×25 cm. 1946. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price $4.75.

CHARLES DARWIN AND THE VOYAGE OF THE BEAGLE. Edited with an Introduction by Nora Barlow. Cloth. 279 pages. 13×21 cm. 1946. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

ENDLESS HORIZONS, by Vannevar Bush. Introduction by Dr. Frank B. Jewett. Cloth. Pages viii+182. 15×23 cm. 1946. Public Affairs Press, 2153 Florida Avenue, Washington 8, D. C. Price $2.50.

PRACTICAL ELECTRICAL MATHEMATICS, by William Edward Rasch, M.A., *Teacher, Electrical Department, Washburne Trade School, Chicago, Illinois.* Cloth. Pages viii+360. 12.5×18.5 cm. 1946. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.00.

INTRODUCTION TO COOLEGE MATHEMATICS, by Carroll V. Newsom, *Professor of Mathematics, Oberlin College.* Cloth. Pages vii+344. 14.5×23 cm. 1946. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $4.65.

A WORKBOOK FOR STUDENTS OF BIOLOGY, by Benjamin C. Gruenberg, *Consultant, Social Security Board,* Formerly *Chairman Biology Departments, Commercial and Julia Richman High Schools, New York City;* Emily Eveleth Snyder, *Teacher of General Science and Biology, Little Falls High School Little Falls New York;* and Jesse V. Miller, *Science Department, Manhasset High School, Manhasset, New York.* Paper. Pages iv+266. 18.5×26 cm. 1946. Ginn and Company, Statler Building, Boston, Mass. Price $1.32.

LABORATORY MANUAL FOR GENERAL ZOOLOGY, by Edward C. Colin, *Chicago Teachers College, Chicago, Illinois.* Loose-Leaf. Planographed.

Pages v+79. 21.5×28 cm. 1946. Werkman's Book Store, 350 West 69th Street, Chicago 21, Ill. Price $1.10.

THE FIRST HUNDRED YEARS OF THE SMITHSONIAN INSTITUTION, 1846–1946, by Webster P. True, *Chief of the Editorial Division of the Institution.* Paper. Pages viii+64. 39 additional pages of illustrations. 17.5×25.5 cm. The Smithsonian Institution, Washington, D. C.

SCIENCE IN THE WILLIAM MCGUFFEY HIGH SCHOOL, by J. S. Richardson, *Miami University*, Oxford, Ohio. Paper. 37 pages. 17.5×21.5 cm. 1946.

EDUCATION IN COLOMBIA, by John H. Furbay, *Senior Specialist on Education in Latin American Countries, Division of Comparative Education.* Bulletin 1946, Number 6. Pages vi+111. 14×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents.

EDUCATION IN COSTA RICA, by John H. Furbay, *Senior Specialist on Education in Latin American Countries, Division of Comparative Education.* Bulletin 1946, Number 4. Pages v+62. 14×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

NUCLEONICS. Prepared under the Auspices of the U. S. Navy Department. Paper. 38 pages. 21×28 cm. 1946. Progress Press, 2153 Florida Avenue, Washington 8, D. C. Price $1.00.

GENERAL EDUCATION BOARD, ANNUAL REPORT 1945. Paper. Pages ix+136. 14×22 cm. General Education Board, 49 West 49th Street, New York, N. Y.

PUBLIC RELATIONS FOR RURAL AND VILLAGE TEACHERS. Bulletin 1946, Number 17. Pages iv+50. 15×23.5 cm. Superintendeent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

THE SCIENTIFIC AND TECHNICAL ASPECTS OF ATOMIC ENERGY CONTROL. First Report of the Scientific and Technical Committee. Paper. Pages v+42. 15×23 cm. 1946. Columbia University Press, Morningside Heights, New York 27, N. Y. Price 25 cents.

THE PACKET. Health's Service Bulletin for Elementary Teachers. Volume I, Number 3, October 1946. 34 pages. 13.5×20.5 cm. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass.

SERVING THROUGH SCIENCE. A Series of Talks Delivered by American Scientists, on the New York Philharmonic-Symphony Program. Paper. 120 pages. 16.5×23 cm. 1946. Sponsored by United States Rubber Company.

SLIDE RULE SHORT CUTS, by W. P. Miller, E.E. Second Edition. Paper. 15 pages. 15×23 cm. 1946. W. P. Miller, 536 F Street, San Diego 1, Calif. Price $1.50.

SCHOOL SOUND SYSTEMS, by the Joint Committee on Standards for School Audio Equipment. Paper. 31 pages. 21×28 cm. 1946. U. S. Office of Education, Washington 25, D. C.

PATHFINDING IN RADIO. The Story of RCA Research and Development. Paper. 40 pages. 21.5×28 cm. Department of Information, Radio Corporation of America, 30 Rockefeller Plaza, New York, N. Y.

BOOK REVIEWS

CIRCUIT ANALYSIS BY LABORATORY METHODS, by Carl E. Skroder, *Associate Professor of Electrical Engineering, University of Illinois*, and M. Stanley Helm, *Assistant Professor of Electrical Engineering, University of Illinois*. Cloth. Pages xvi+288. 15×23 cm. 1946. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11 N. Y. Price $5.35.

This new text is in the nature of a laboratory manual or guide to be used at the level of the first course in electrical engineering covering d-c and a-c circuits. Much of the beginning work of the text is over material that the student should already know from his course in college physics. Since this is a more specialized text, the description and uses of each type of electrical apparatus is given so much more thoroughly than can be done in the general physics course that it is probably well for the student to review and expand his knowledge of the apparatus that is used in circuit analysis.

The authors soon get into the more specialized and typical engineering apparatus such as d-c and a-c machinery and also into the more advanced circuit analysis by the application of Kirchhoff's laws to a-c circuits. The principles of the series and parallel a-c circuits are well covered both in theory and experiment. Methods of circuit measurements and analysis of polyphase circuits are thoroughly covered. The vector representation of a-c currents and voltages is used both graphically and analytically.

Probably one of the best features of the text from the pedagogic point of view is the sound orientation advice to the student in establishing the proper scientific attitude. This is further enhanced by a very thorough discussion of general laboratory procedure. A chapter is devoted to instructions in writing the report, which is a phase engineering work that is so often slighted in engineering instruction, yet is so important to the success of an engineer when he finds in practice that he must convey his ideas and findings to others in written form.

The authors, editor and publishers are to be complimented on an excellent addition to their Electrical Engineering Series of texts.

H. R. VOORHEES
Chicago City Junior College
Herzl Branch

INTERNATIONAL PAYMENTS; A SCIENCE, by Ray Ovid Hall. Cloth. Pages xi+124. 21×28 cm. 1946. Ray Ovid Hall, 1763 Columbia Road, Washington 9, D. C. Price $4.00.

The author presents a method by which he claims it possible to prove that one figure in a balance of international payments is erroneous by the use of approximately thirty other figures appearing in other balances of payments. He terms this method "Four-Element Analysis" and calls it "a new mathematics." The material would seem to be of interest primarily to statisticians or economists—some of these may question its validity. Certainly some of the wording of the textual material is not in customary mathematical phrasing. This monograph will probably be of little interest to the majority of secondary school teachers.

CECIL B. READ
University of Wichita

MATHEMATICS IN LIFE; BASIC COURSE, by Raleigh Schorling, *Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan;* and John R. Clark, *Professor of Education, Teachers College, Columbia University*. Cloth. Pages xii+500.

15×24 cm. 1946. World Book Company, Yonkers-on-Hudson 5, N. Y. Price $1.80.

This is a textbook organized on the unit basis for students on the secondary school level. It is planned for a course in general mathematics which would cover basic concepts of importance in many occupations. The authors hope to reach goals suggested in the second report of the Commission on Post-War Plans of the National Council of Teachers of Mathematics. The authors seem to be very successful in attaining their objective.

An unusual feature is the extensive amount of reading material which may or may not clarify the concepts. The authors feel that this material leads the student into the subject. There are many practice tests with answers in the back of the book. In general, practical applications are stressed as opposed to theory. In fact, in some cases this is carried to such an extent that a student might gain the impression that a special case constitutes a proof of a general theorem. There is extensive work on decimals including some good material on approximate computations; a very fine material on budgeting, taxation, insurance, and similar problems; some elementary algebra, practical geometry, and elementary trigonometry; also some very good material on graphic representation. There is a good index, the typography and illustrations are excellent.

CECIL B. READ

AN INTRODUCTION TO ORGANIC CHEMISTRY, by the late Alexander Lowry, Ph.D., and Benjamin Harrow, Ph.D. Sixth Edition, Revised by Benjamin Harrow, Ph.D., *Professor of Chemistry*, and Percy M. Apfelbaum, Ph.D., *Assistant Professor of Chemistry*. Both at the City College, The College of the City of New York. Cloth. Pages xiv+448. 13.5×21.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.50.

The sixth edition of *An Introduction to Organic Chemistry* has the same general purpose as had previous editions—the inclusion of material which can be satisfactorily covered in a one year course in organic chemistry. This edition marks the appearance of a new co-author to replace the senior author, the late Alexander Lowry.

Revision has enabled the authors to bring the textual material up to date, to emphasize modern theories of organic chemistry, and to rewrite and to clarify material included from previous editions. Increased emphasis is placed on the electron theory of valence and on resonance.

The text consists of thirty-seven chapters—eighteen devoted to the aliphatic series and fifteen to the aromatic series. The last four chapters cover respectively: the identification of organic compounds; plant and animal pigments; enzymes, vitamins, hormones; and nomenclature of organic compounds.

Noteworthy features of the text are the charts illustrating the uses of important organic chemicals and the excellent series of questions at the end of each chapter. The list of references at the end of the book has been extensively revised and now covers eight pages.

The style is excellent; the print is clear; and the choice of material included is of such a nature that the text can be used equally well in courses designed for chemistry majors and for students preparing for careers in medicine and other professional fields.

A. L. BURLINGAME
Chicago City Junior College
Wilson Branch

CHEMISTRY: A COURSE FOR HIGH SCHOOLS, by John C. Hogg, A.M., M.A., *Chairman, Science Department, The Phillips Exeter Academy, Exeter, New Hampshire;* Otis E. Alley, Ph.D., *Head of Science Department, Winchester High School, Massachusetts;* and Charles L. Bickel, Ph.D., *Instructor in Science, The Phillips Exeter Academy, Exeter, New Hampshire.* Cloth. Pages viii+544. 15×23 cm. 1945. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

Chemistry: A Course for High Schools, should fulfill its intended purpose of stimulating the student to interest in further study. The material is exceedingly well written and profusely illustrated with pictures, diagrams, and charts. The type is large; important points are emphasized by bold face type; and the material is so arranged that no page presents an unbroken mass of printed material.

The text follows the conventional order of topics but emphasizes the applications of chemistry without neglecting theory. It consists of three parts, each divided into two units of several chapters.

A high school teacher will be particularly interested in these features of the book:

1. A series of experiments in the body of each chapter set off from the text by smaller type.
2. A number of type problems—each carefully worked out.
3. A chapter summary—"Things to Remember."
4. An ample supply of both study questions and problems—the latter divided into two groups, A—the simpler problems, and B—the more difficult problems. Answers are supplied for about one-third of the problems.
5. Review exercises at the end of each unit.

Few mistakes are apparent in the text, but it is to be regretted that the authors present the cathode reaction in the electrolysis of an aqueous solution of sodium chloride as the initial discharge of a sodium ion followed by the reaction of the liberated sodium atom with water to form hydrogen and sodium hydroxide.

A. L. BURLINGAME

ESSENTIALS OF GENERAL CHEMISTRY, by B. Smith Hopkins, *Professor of Inorganic Chemistry, Emeritus,* and John C. Bailer, Jr., *Professor of Chemistry, University of Illinois.* Cloth. Pages v+520. 14.5×22.5 cm. 1946. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.50.

The order of presentation of material in *Essentials of General Chemistry* is conventional. Chapter 1 takes up such fundamental principles as: chemical and physical change; conservation of matter and of energy; the metric system; mixtures, compounds, and elements; molecules and atoms; symbols, formulas, and equations; and atomic weights and the gram molecule.

Chapter 2 deals with oxygen and chapter 4 with hydrogen. Here oxidation-reduction is introduced in terms of gain and loss of oxygen. In chapter 3 the structure of the elements with atomic numbers from one to twenty is presented; and isotopes, electrovalence, and covalence are discussed. Chapter 5 is devoted to kinetic theory and the gas laws, and chapter 6 takes up water and hydrogen peroxide. In the latter chapter, the authors carefully distinguish between the terms peroxide and dioxide and use material which logically belongs in this chapter to develop the law of multiple proportions.

Henry's law, the evidence for the presence of ions in solution, and the effect of the solute on the solvent are clearly presented in chapter 7.

Five chapters are concerned with: chlorine; hydrogen chloride, hydrochloric acid; electrolytic oxidation and reduction; the oxygen compounds of chlorine; and the other halogens. In them the authors develop the methods of balancing equations involving change as well as no change in oxidation number. In their chapter on acids and bases, they stresss the hydration of the hydrogen ion. Two chapters are devoted to sulphur and its compounds; four chapters to nitrogen, nitrogen compounds, and members of the nitrogen family; a single chapter to silicon and boron; and three chapters to carbon, hydrocarbons, and hydrocarbon derivatives.

Chapter 25 introduces the metallic elements and emphasizes the differences between metals and non metals. Beginning with chapter 26 the metals are discussed in order of the periodic table.

Noteworthy features of this book are chapter summaries of new terms presented, and a series of literature references. Electronic formulas showing the valence electrons by means of dots and crosses are a feature of the entire text.

Many college chemistry teachers will regret that so little space is devoted to the development of atomic structure; that radioactivity, both natural and artificial, is entirely neglected; and that the topics of equivalent weights and determination of formulas are not presented.

The text is not inclusive but covers clearly and interestingly that material which the authors believe essential to freshman college chemistry.

A. L. BURLINGAME

VITALIZED PHYSICS, by Robert H. Carleton, *Head of Department of Science, Summit High School, N. Y.* Edited by Michael N. Idelson, *Head of the Department of Physical Sciences, Abraham Lincoln High School, Brooklyn, New York.* Revised Edition. Paper. Pages ii+378+iv. 12.5×18.5 cm. 1946. College Entrance Book Company, 104 Fifth Avenue, New York 11, N. Y. Price 65 cents.

Vitalized Physics is an inexpensive physics book that attracts the attention of high school students. It is low in cost, small in size, and is intended to be a student s permanent guide and stand-by whenever a memory refresher may be needed. Through graphicolor presentation the 200 diagrams are outstanding in content and execution, large, striking, simplified, and accurate. The authors who are experienced high school teachers have motivated the text with illustrations, references, examples and applications that are within the environment of the modern high school student.

Thought questions, objective tests, and problems with answers given in red help to stimulate correct *observation* of diagrams, illustrations, applications, etc.

Quantitative treatment of type problems emphasize the importance of accurate *measurement.*

Attractive two color formulae are presented as mathematical tools with which the student may do this *thinking* about physical things.

The chapters that are outstanding, are Mathematics Used in Physics, Alternating Currents, Aeronautics, Radio, and Meteorology.

ESTIL B. VAN DORN
Washington High School
Indianapolis, Indiana.

MATHEMATICS AND LIFE—Books 1 & 2 by F. B. Knight, *Head of Education Department, Purdue University;* J. W. Studebaker, *Commissioner of Education;* Gladys Tate, *Mathematics Teacher, Erie, Pa.* Cloth: Book 1,

480 pages; Book 2, 512 pages: 14×19 cm. 1946. Scott, Foresman & Company, Chicago, Ill.

These texts are designed for students of arithmetic in grades 7 & 8 and follow "Study Arithmetics," grades 3 through 6 published by the same company. These texts might well be considered a revision of "Mathematics and Life" or "Study Arithmetics" by Ruch, Knight and Studebaker, published in 1937. However the organization has been changed some, statistical material has been brought up to date as have the facts of problem material such as wages, cost of goods, time, etc. The front and back cover and fly leaf are used as a pictorial index, a feature which should appeal to students. The only other index is, "Index of Mathematical Content," found in the back of the book.

The chapter headings are of a social nature, with grade seven built around the home, such as: Home Mathematics, Earning a living, Managing an income, etc. Grade eight is built around the community with headings like; Mathematics and the Community, The Merchant and the Community, Business and the Community, etc. Each chapter has a social introduction however the content emphasizes the mathematical almost wholly. In a few cases the problem material developes a social topic but in most cases there are a number of problems on different social situations which apply the same mathematical principle. Precise measure has been confused with exact and the place of approximate measure and computation is not clearly presented or applied. A discussion is given but it is not related to problems where measure is used.

Very good use is made of black, white, and colored pictures, many of these show boys and girsl at work in school. The use of decimals and percents has been emphasized in both books. In book 1 pages 103 to 289 show various applications including those of over 100%. A few tables are given but they are used very little in the problem material. The work on measure covers most areas of all common forms. Some items have been reduced greatly such as algebra in book 2, installment buying, stock and bond work, the metric system and insurance. In the illustrative examples dealing with units of measure the authors have erred in giving results such as, "the area is 99 or 99 square feet," as found on page 36 to 48. This may lead the student to feel either is correct.

There are a number of very good special features; problem sets for mental arithmetic; remedial sets of problems; questions after problems asking for reasonableness of results; "Side Trips" which are historical and broadening; problems for good thinkers and "Checking up" a maintenance device. Due to the many illustrative examples set up clearly the teacher will need to be on guard so rote learning does not replace understanding. These books have sufficient problem material well applied, will be easy to teach and will hold the interest of the pupil.

PHILIP PEAK
University School,
Bloomington, Ind.

SOUL OF LODESTONE, by Alfred Still, *Fellow, American Institute of Electrical Engineers; Member, Institution of Electrical Engineers (London)*. A companion Volume to *Soul of Amber*. Cloth. Pages x+233. 14×21 cm. 1946. Murray Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $2.50.

This book is a companion to the *Soul of Amber* which we reviewed in a previous issue. It is probably correct to say that the physics teacher knows less about magnetism than any other part of his subject. This is true both

because relatively little is known about magnetism and, much that is known, is not essential to a practical knowledge of magnetism and electricity. The author here does not aim to tell much of magnetism but confines his story to the magnets of nature. Mr. Still is one of the few physicists who has made a thorough study of this subject. In this little book he not only tells the reader much of the known story of the lodestone but also gives many of the errors made by the early experimenters and by those who made statements without any serious attempt to get at the facts. Each chapter is followed by a number of notes which frequently give sketches of the lives of men mentioned in the text. Much of the history of science in the ancient world and in medieval times is given to show the progress of scientific (and non-scientific) thinking about the lodestone. A list of the chapter headings will indicate the nature of the story as here developed (I) The Lodestone in Ancient Times, (II) The Dark Ages and the Decline of Science, (III) The Orgin of the Magnetic Compass, (IV) William Gilbert and His Era, (V) This Great Magnet, the Earth, (VI) Magnetism after Gilbert, (VII) Systems and Conjectures, (VIII) The Modern Touch.

G. W. W.

NATIONAL COUNCIL OF GEOGRAPHY TEACHERS

SECOND ANNUAL PROGRAM

Boston Convention of the AAAS
December 27–31, 1946

Convention Headquarters: Oak Room; Hotel Bradford

THURSDAY EVENING SESSION, DECEMBER 26

8:00 P.M.; Meeting of NSTA Committee on Arrangements; Bradford Glass Room

FRIDAY MORNING SESSION, DECEMBER 27

10:00 A.M.; Cooperative Committee on Science Teaching of the AAAS; Hotel Bradford, Parlor A.

OLIVER J. LEE, *Presiding*

LEFLER, R. W. Science Counseling in Secondary Schools.
LARK-HOROVITZ, K. Certification of Science Teachers.
SCHORLING, R. The Crisis in Science Teaching.

FRIDAY AFTERNOON SESSION, DECEMBER 27

2:30 P.M.; Junior Scientists Assembly; Bradford Lobby Ballroom.

SATURDAY MORNING SESSION, DECEMBER 28

(At the Massachusetts College of Pharmacy, 179 Longwood Avenue. Take Huntington Avenue subway car at Park Street and get off at Longwood Avenue)

All Sections meet in Room 211

9:30 A.M.; MORRIS MEISTER. Activities of the National Science Teachers Assn.

Physics Section in Room 214

ELDIN V. LYNN, *Presiding*

10:00 A.M.; SEARS, FRANCIS W. American Army University of England.
10:45 A.M.; DEUTSCH, MARTIN W. Some Aspects of Sub-Atomic Technology.

Chemistry Section in Room 213

ELBERT C. WEAVER, *Presiding*

10:00 A.M.; SANFORD, JANET. A Silk Purse from a Sow's Ear.
10:45 A.M.; HAUSER, ERNST A. Science and Technology of Colloidal Clays.

General Science Section in Room 212

RALPH E. KEIRSTEAD, *Presiding*

10:00 A.M.; THURBER, WALTER A. Looking Ahead in the general Science Program.
10:45 A.M.; General Discussion.

For Teachers of Biology

Program of the National Association of Biology Teachers;
Bradford Lobby Ballroom

9:00 A.M.; Symposium on Ecology and The Teaching of Biology.
What in Ecology is Most Significant to the Biology Teacher?

SATURDAY NOON SESSION, DECEMBER 28

12:30 P.M.; Annual Luncheon of the National Science Teachers Association Salle Modern, Hotel Statler.

OTIS W. CALDWELL *Presiding,*

2:00 P.M.; Program of the National Association of Biology Teachers; Parler B. Hotel Bradford.
The Teaching of Ecology.

SATURDAY EVENING SESSION, DECEMBER 28

6:30 P.M.; Dinner of the National Association of Biology Teachers; Hotel Bradford.

MONDAY MORNING SESSION, DECEMBER 30

(At the Massachusetts College of Pharmacy, 179 Longwood Avenue. Take Hungtington Avenue subway car at Park Street and get off at Longwood Ave.)

9:30 A.M.; All Sections meet in Room 211.
SOLLBERGER, D. E. Time for Science Teaching—The 1946 NSTA Yearbook.
SLYE, BERTHA E. Science Teaching Packets, an NSTA Project.

Physics Sections in Room 213

JAMES W. DYSON, *Presiding*

10:00 A.M.; Difficulties and Demonstrations in Physics, by members of the Boston Secondary School Staff.

Chemistry Section in Room 211

HELEN CRAWLEY, *Presiding*

10:00 A.M.; Demonstrations and Difficulties in Chemistry, by members of the Boston Secondary School Staff.

General Science Section in Room 212

LEO J. FITZPATRICK, *Presiding*

10:00 A.M.; Demonstrations and Difficulties in General Science, by members of the Boston Secondary School Staff.

National Council of Geography Teachers

Neil House, Columbus, Ohio
December 27 and 28

9:30 Friday Morning, December 27—GENERAL SESSION: *The Challenge. Greetings to the National Council.* Mary E. Case, President of the Ohio Council of Geography Teachers, Kensington School, Rocky River, Ohio

Response. Thomas F. Barton, Second Vice-President of the National Council, Southern Illinois Normal University, Carbondale, Illinois

The New Meaning of Geography in Education. Wallace W. Atwood, Worcester, Mass.

10:45 Friday Morning, December 27—ROUND TABLE DISCUSSIONS: *National Council at Work*

A. *Geographic Education for World Understanding*
B. *What Program to Further Out-of-Door Education Should Be Undertaken by the National Council?*
C. *How Can Geography Be Made More Functional in Everyday Life?*
D. *National Council Activities in Aviation Geography*
E. *Have We Satisfactory Motion Pictures for Teaching Geography?*
F. *What Standards Should be Set for Wall Maps?*

2:00 P.M. Friday, December 27—GENERAL SESSION: *Teaching Geography —Problems, Materials, Experiences*

A. *Problems and Experiences in Teaching Geography to High School Seniors*
B. *G.I. Geography in England*
C. *Looking Forward in Educational Geography*
D. *The Problem of Supplementary and Recreatory Materials in Geography*
E. *Problems and Materials for Geographic Studies in Industrial Geography*
F. *Meeting the Problem of Materials for Resource-Use Education in Alabama*

6:30 P.M. Friday, December 27—ANNUAL DINNER

The Population Prospect in Relation to the World Agricultural Resources. Oliver F. Baker, University of Maryland

Reception in honor of the recipients of the Distinguished Service Award

10:00 A.M. Saturday, December 28—GENERAL SESSION: *The Curriculum in Geography*

A. *World Events and Their Implications for the Geography Curriculum*
B. *Developments in the Field of Geography and Their Implications for the Geography Curriculum*
C. *Educational Trends and Their Implications for the Geography Curriculum*
D. *A City Builds a Curriculum*

12:15 P.M. LUNCHEON MEETINGS—*The Geography Curriculum at Various Levels.* Sat. Dec. 28

A. *Geography in the Elementary School*
What Shall We Teach in the Elementary Schools?
B. *Geography in the High School*
Contributions of High School Geography to Education for Citizenship
Geography in the Work of the U. S. Office of Education

C. *Geography in the College*
Post-War Trends in American Colleges and Some Implications for Geography

2:00 P.M. Saturday, December 28—GENERAL SESSION. *Organization for Work*
Presentation of a Proposed New Constitution
The Year 1946, An Accounting—Reports from Officers and Committee Chairmen
The National Council of Geography Teachers as a Working Organization

---

HOW SCIENCE TEACHERS MAY OBTAIN GOVERNMENT PUBLICATIONS

PHILIP G. JOHNSON, *Specialist for Science,*
Division of Secondary Education
U. S. Office of Education,
Washington 25, D. C

Many requests about the availability of government publications on a wide variety of topics are received in the United States Office of Education. The teachers who make the requests have an idea that there may be a bulletin available for their desired item of information. They do not know where to locate or secure it. In many cases, teachers are correct in thinking that authoritative information is available. It may be possible for them to secure what they want and, in addition, many other publictaions which can be of help to them and to their students.

A. HOW TO DISCOVER WHAT IS AVAILABLE:

Check the printed copy of available Price Lists to indicate the lists you desire. Fill in your name and address and mail it to the Superintendent of Documents, Government Printing Office, Washington 25, D. C. (There is no charge for these lists.)

B. HOW TO SECURE THE PUBLICATIONS YOU DESIRE:

Use the order blank which you will receive with the Price Lists and order the publications you desire. Enclose remittance as instructed. Your school librarian may be willing to do the ordering for you and pay for the publications from library funds. Your principal or superintendent may provide funds for this purpose. You may wish to develop your own library by paying the modest charges yourself. It is possible that a number of your students may wish to order some of the publications described in the Price Lists.

C. HOW TO KEEP IN TOUCH WITH SELECTED NEW RELEASES:

Write a card or letter to the Superintendent of Documents and ask that your name be included among those who receive the semimonthly List of Selected United States Government Publications. This list announces twice a month a few of the new releases which are of general public interest. Annotations and prices are included. There is no charge for this leaflet.

D. HOW TO KEEP INFORMED ABOUT ALL NEW RELEASES:

Arrange for a subscription to the Monthly Catalog of United States Government Publications. The school librarian may obtain this catalog for use by all school employees or you may become a personal subscriber. This catalog is issued by the Superintendent of Documents at $2.25 a year

domestic delivery and $2.85 per year foreign. This catalog lists the publications of all departments issued during each month, whether for sale or otherwise, quoting prices in all instances where the publication is for sale.

Here are a few examples of publications which were selected from several of the lists of publications and currently available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.:

History of Water Witching, with Bibliography. 1938. 59 p. (Geological Survey, Water-Supply Paper 416). 15¢.

Pendulum Gravity Measurements and Isostatic Reductions. 1942. 82 p. (Coast and Geodetic Survey, Special Publication 232). Cloth $1.00.

Cancer posters (1941). Each 28×22 inches, 4 different posters at 5¢ each. (Public Health Service).

International Metric System (chart). 28.1×44.1 inches. (Standards Miscellaneous Publication 3). 40¢.

A General Account of the Development of Methods of Using Atomic Energy for Military Purposes Under the Auspices of the United States Government. 1940–45. By H. D. Smythe. 35¢.

Science the Endless Frontier. Report to the President on a Program for Post-war Scientific Research. By Vannevar Bush. 30¢.

Story of Radar, by John M. Hightower (1943). 19 p. (78th Congress 1st Session; S doc. 89). 10¢.

Radar—A Report on Science at War. 15¢.

Several divisions of the government issue separate lists of publications. Many of these publications are available free until the free supply is exhausted. Some publications are for sale only. If teachers have a special interest in the publications of any one division, they may wish to write directly to that division asking that the list of available publications and the monthly lists of new releases be sent to them.

How to Keep in Touch

A semimonthly *List of Selected United States Government Publications for Sale by the Superintendent of Documents*, arranged alphabetically by subjects, with annotations and prices, may be obtained free upon application. If you wish to keep in touch with the issuance of all United States public documents, place a subscription for the *Monthly Catalog of U. S. Public Documents*, which is priced at $2.25 a year domestic delivery, and $2.85 per year foreign. This catalog lists the publications of all departments issued during each month, whether for sale or otherwise, quoting prices in all instances where the publications are for sale.

The accumulation of publications in this office amounts to several millions, of which over two million are assorted, forming the sales stock. Many rare books are included, but under the law all must be sold regardless of their age or scarcity. Many of the books have been in stock some time and are apt to be shop-worn. In filling orders the best copy available is sent.

Document Catalogs and Indexes issued by this office may be consulted in all large libraries, most of which also keep at hand, for the use of the public, a set of our subject price lists.

There is no free distribution of Government publications by this office, it being the sales department for Government publications as instituted by law.

No catalog showing under one cover all Government publications is issued, as it would be too voluminous for practical use.

Price Lists

GOVERNMENT PUBLICATIONS

These price lists are issued by the Superintendent of Documents, Government Printing Office, Washington 25, D. C. They describe each available book or pamphlet, and embrace current topics as follows:

- ☐ **10 Laws.** Federal statutes and compilations of laws on various subjects.
- ☐ **11 Foods and Cooking.** Home economics, household recipes, canning, cold storage.
- ☐ **15 Geological Survey.** Covers geology and water supply.
- ☐ **18 Engineering and Surveying.** Leveling, tides, magnetism, triangulation, and earthquakes.
- ☐ **19 Army and Militia.** National defense, veterans' affairs.
- ☐ **20 Public Domain.** Public lands, conservation, National Resources Planning Board.
- ☐ **21 Fish and Wildlife Service,** and other publications relating to fish and wildlife.
- ☐ **24 Indians.** Publications pertaining to Indians, anthropology, and archaeology.
- ☐ **25 Transportation and Panama Canal.** Railroad and shipping problems, postal service, communications, Coast Guard, Panama Canal.
- ☐ **28 Finance.** Banking, securities, loans.
- ☐ **31 United States Office of Education,** and other publications relating to education.
- ☐ **32 Insular Possessions.** (Philippines, Puerto Rico, Guam, American Samoa, Virgin Islands.)
- ☐ **33 Labor.** Child labor, women workers, wages, workmen's insurance and compensation.
- ☐ **35 Geography and Explorations.** National parks, guidebooks.
- ☐ **36 Government Periodicals,** for which subscriptions are taken.
- ☐ **37 Tariff.** Compilation of acts, decisions, and regulations, relating to tariff, taxation, and income tax.
- ☐ **38 Animal Industry.** Domestic animals, poultry and dairy industries.
- ☐ **41 Insects.** Bees and honey, and insects harmful to man, animals, and plants.
- ☐ **42 Irrigation, Drainage, Water Power.** Federal Power Commission, water resources.
- ☐ **43 Forestry.** National forests, ranges, lumber and timber, American woods.
- ☐ **44 Plants.** Culture of fruits, vegetables, cereals, grasses, grain.
- ☐ **45 Roads.** Construction, improvement, and maintenance.
- ☐ **46 Agricultural Chemistry and Soils and Fertilizers.** Chemistry of foods, soil surveys, soil erosion, and conservation.
- ☐ **48 Weather, Astronomy, and Meteorology.** Climate, floods, aerological observations.
- ☐ **49 Proceedings of Congress.** Bound volumes of Congressional Record and Congressional Globe.
- ☐ **50 American History and Biography.** The Revolution, Civil War, World War.
- ☐ **51 Health.** Diseases, drugs, sanitation, water pollution.
- ☐ **53 Maps.** Government maps, and directions for obtaining them.
- ☐ **54 Political Science.** Government, crime, liquors, District of Columbia, Supreme Court, un-American activities.
- ☐ **55 National Museum.** Contributions from National Herbarium, National Academy of Sciences, and Smithsonian reports.
- ☐ **58 Mines.** Explosives, fuel, gas, gasoline, petroleum, minerals.
- ☐ **59 Interstate Commerce.** Steam railways, motor carriers, carriers by water.
- ☐ **60 Alaska and Hawaii.** Mineral and agricultural resources, coal lands, geology, water supply, seal fisheries.
- ☐ **62 Commerce and Manufacturers.** Foreign trade, patents, trusts, public utilities.
- ☐ **63 Navy.** Publications relating to Navy and Marine Corps.
- ☐ **64 Standards of Weight and Measure.** Tests of metals, building materials, electricity, photography.
- ☐ **65 Foreign Relations.** Executive agreements, treaties, neutrality, international conferences.
- ☐ **67 Immigration.** Aliens, citizenship, naturalization, races.
- ☐ **68 Farm Management.** Agricultural credit, farm products, marketing, agricultural statistics.
- ☐ **69 Pacific States:** California, Oregon, Washington. All material relating to these States.
- ☐ **70 Census.** Statistics of population, manufactures, agriculture, occupations.
- ☐ **71 Children's Bureau,** and other publications relating to children.
- ☐ **72 Suburbanites.** Publications of interest to suburbanites and home builders.
- ☐ **75 Federal Specifications.** Federal standard stock catalog.
- ☐ **77 World War II.** National defense, postwar planning.
- ☐ **List of Field Manuals and Technical Manuals.**
- ☐ **List of Radio Publications.**

Please send Price Lists as checked on this sheet to:

Name_____
(Please print)

Street_____

City & State_____

688659—46

over

How to Remit

The rules of this office require that remittances be made in advance of shipment of publications, either by coupons, sold in sets of 20 for $1 and good until used, or by check or money order payable to the Superintendent of Documents. Currency may be sent at sender's risk. Foreign money, defaced or smooth coins are not acceptable. Do not send postage stamps.

Postage is not required for shipment within the United States, including Alaska, Guam, Hawaii, Panama Canal Zone, Philippine Islands, Puerto Rico, Samoa (U.S.), and Virgin Islands (U.S.), nor for shipment to Bolivia, Canada, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras (Republic of), Mexico, Newfoundland (including Labrador) Nicaragua Panama, Paraguay, Peru, Uruguay, and Venezuela. For shipment to all other countries an additional amount of about one-third of the purchase price is required. Remittances from foreign countries should be by international money order, or draft on an American bank, payable to the Superintendent of Documents.

Promptness in handling correspondence is insured by sending separate requests for information instead of embodying them in cash order. Full name and address should be given on request for additional information.

The Superintendent of Documents, Government Printing Office, Washington 25, D. C., is authorized by law to sell copies of Government publications and to allow a discount of 25 per cent on some, to book dealers and quantity purchasers of 100 or more publications, on condition that the purchasers will adhere to the public sales price set by the Superintendent of Documents and that publications shall not be overprinted with any advertising matter.

A NEW COOLANT FOR AIRPLANE ENGINES

More take-off power and a greater load for planes is possible with the use of an internal cooling liquid in the engine, wartime research of the National Advisory Committee for Aeronatics disclosed. The discovery was made public with the release from military security of a report on research conducted by Addison M. Rothrock at the Aircraft Engine Research Laboratory, Cleveland.

Ammonium hydroxide was the liquid coolant inducted through the inlet manifold of the plane's engine. Its use permits 25% more take-off from the fuel. This means an approximate usable increase of 8.5% in the take-off load and increases the plane's rate of climb.

The increase in load is equivalent to an increase in the weight of gasoline carried of between 30% and 65%.

Water used alone as the cooling agent might freeze in cold weather or at high altitudes, so ammonium was mixed with the water to lower the freezing point. Mr. Rothrock says that other coolants may be used depending on availability and ease of handling as well as engine performance.

The four banks of Berkeley, Calif., have divided the city into four areas, each taking responsibility for one section. Every week, each bank sends a bonded messenger to the schools in its area to pick up money and orders for Stamps and Bonds.